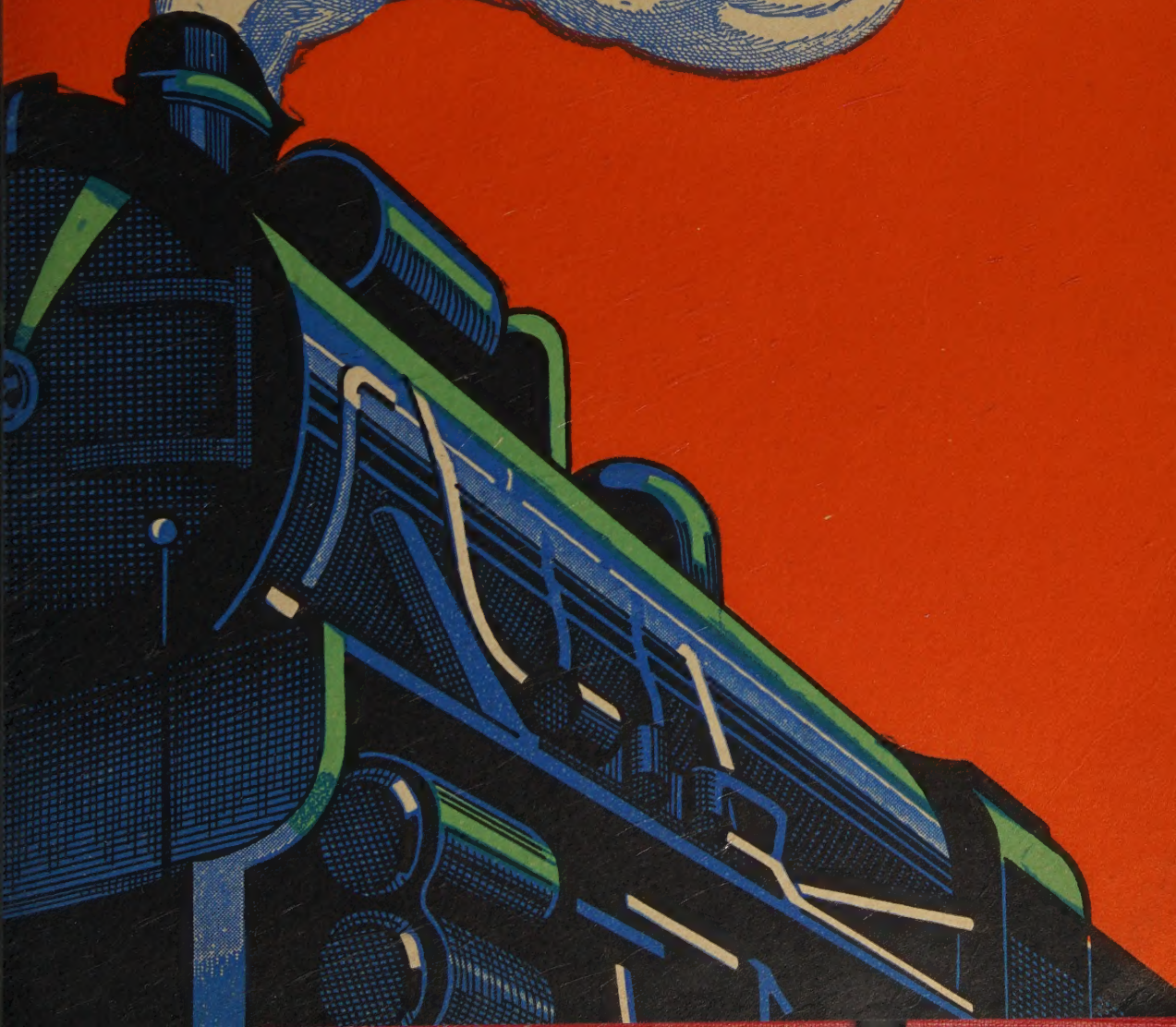
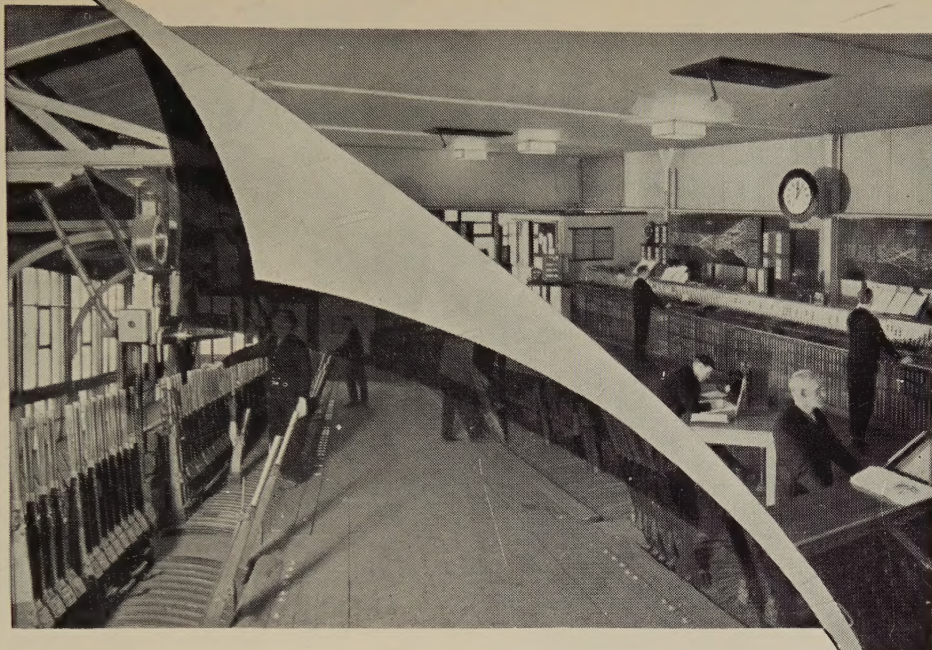


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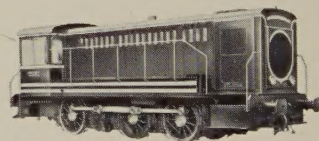
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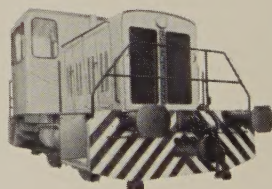


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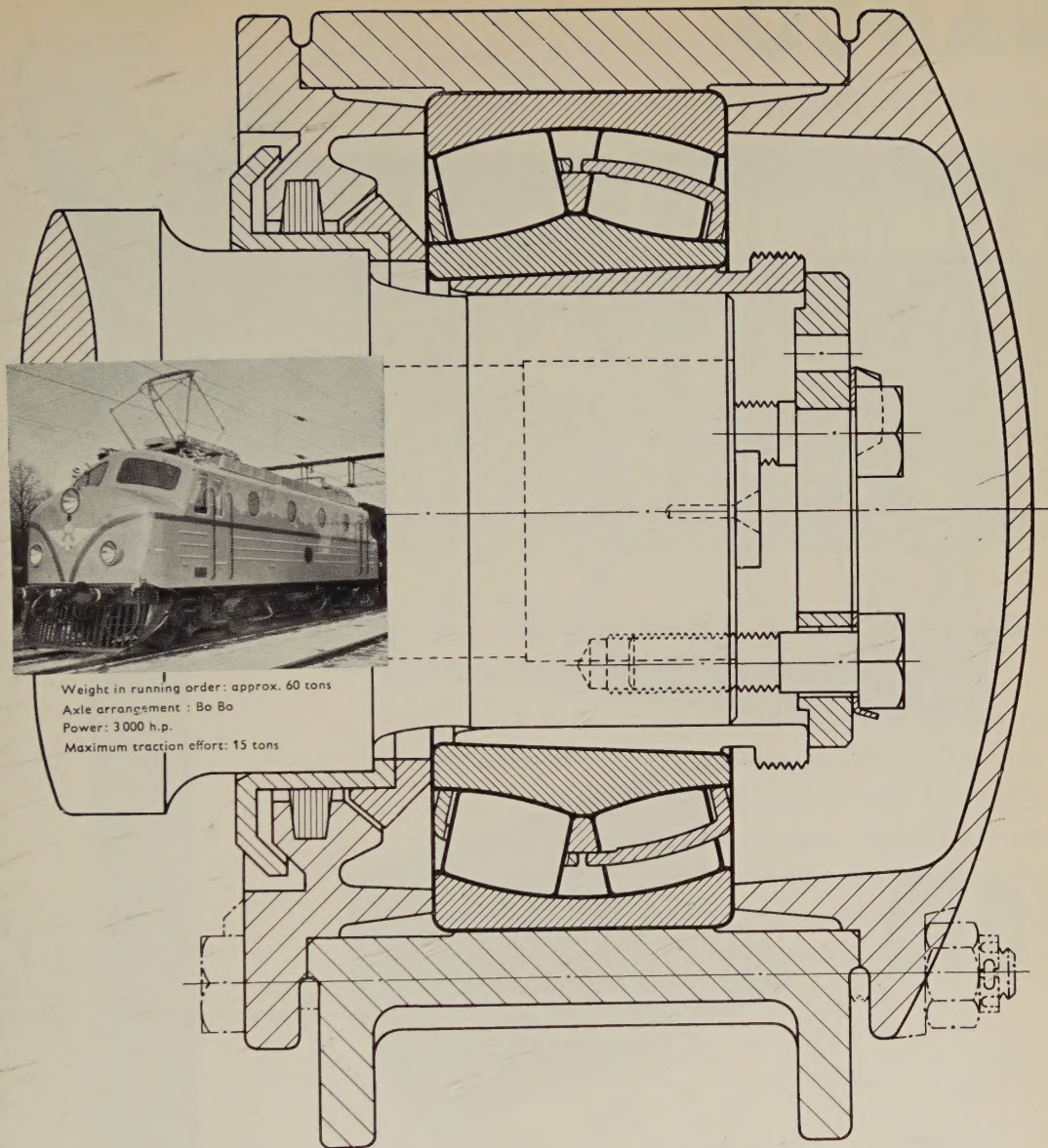
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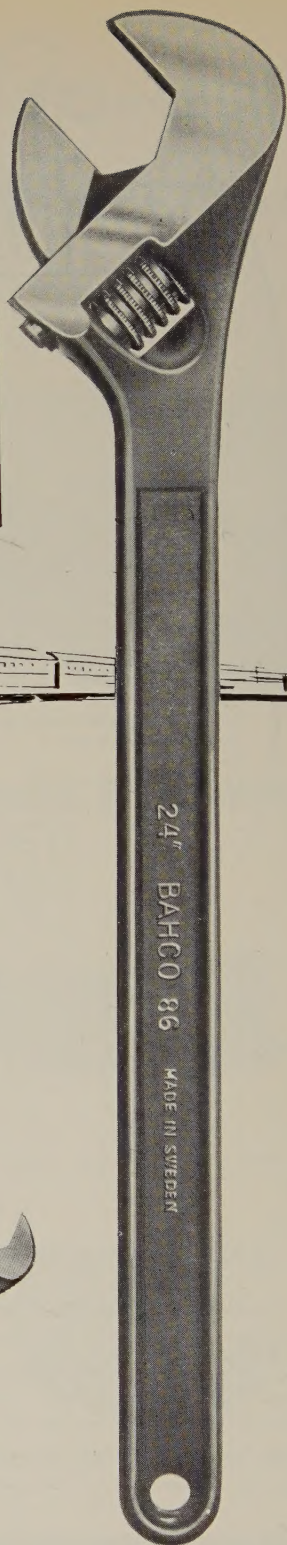
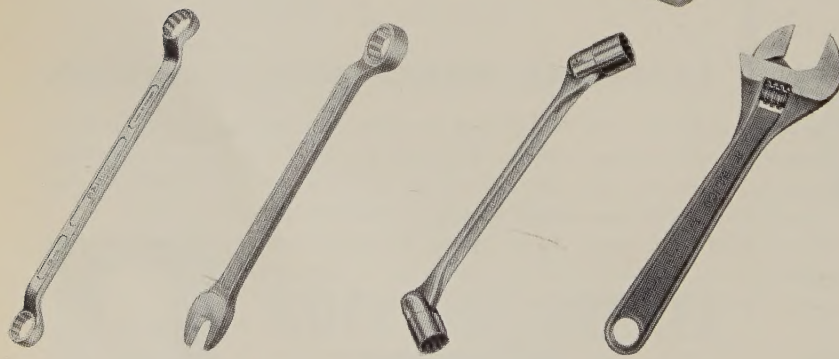
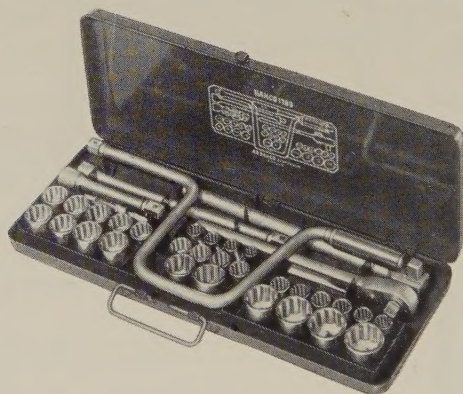
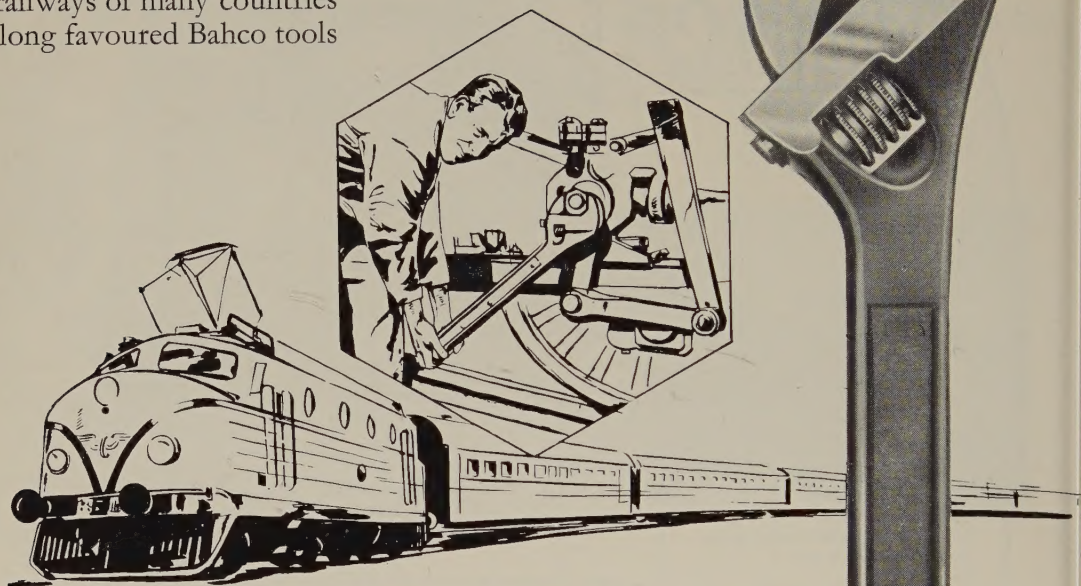
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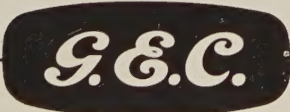
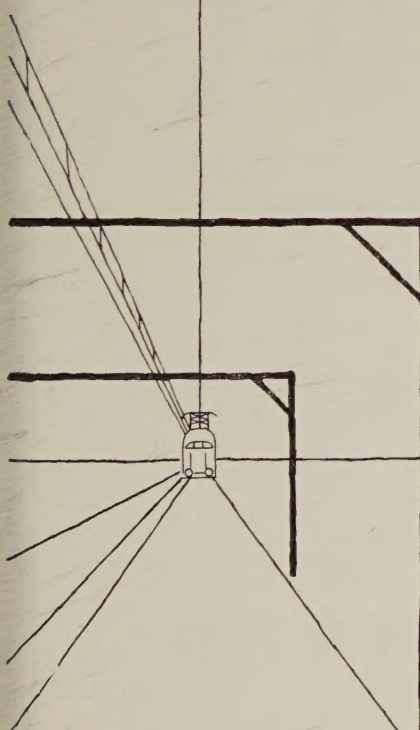


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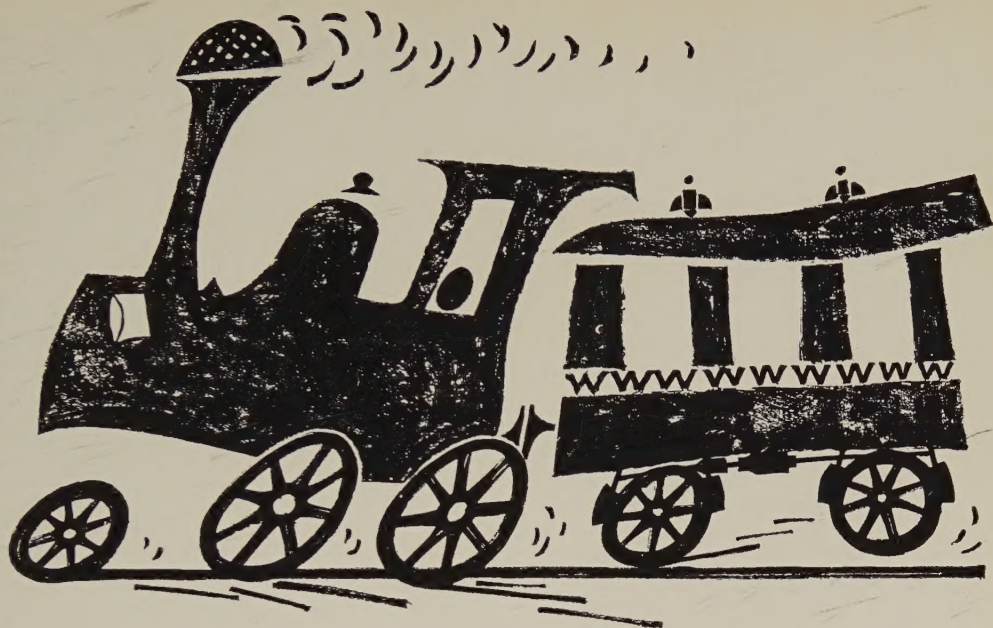
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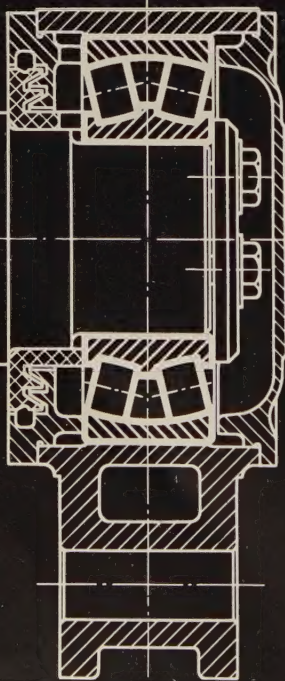
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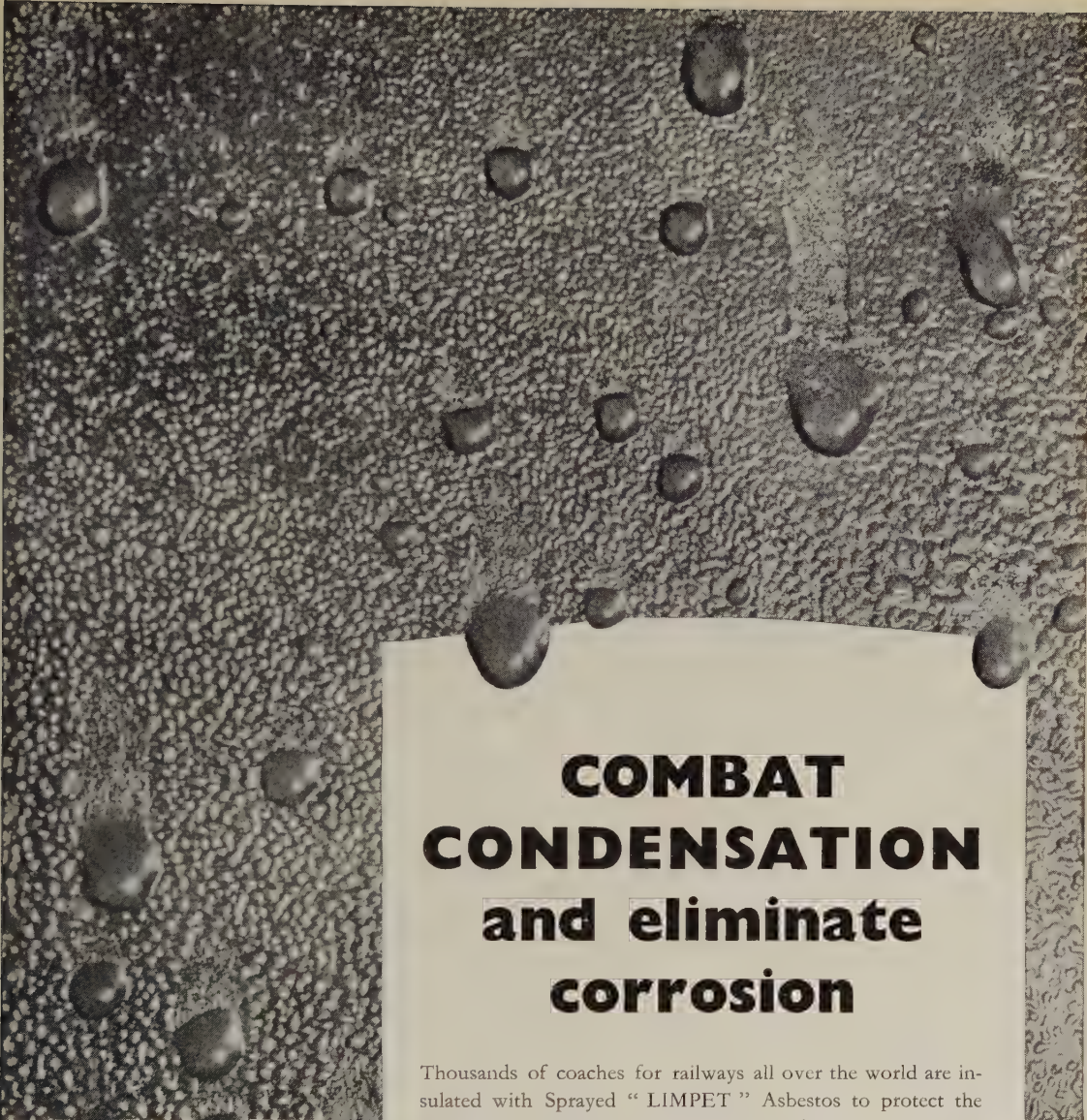
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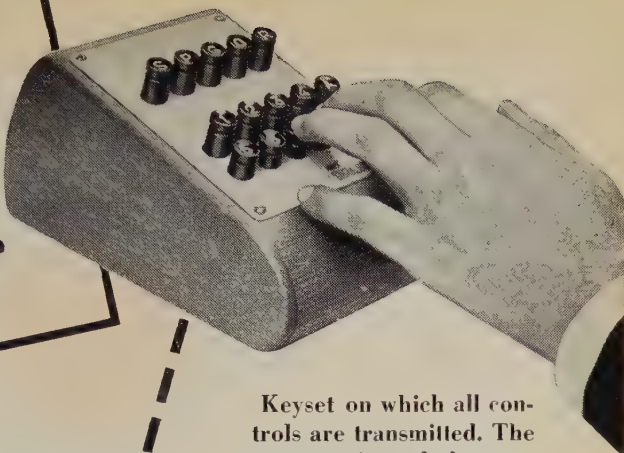
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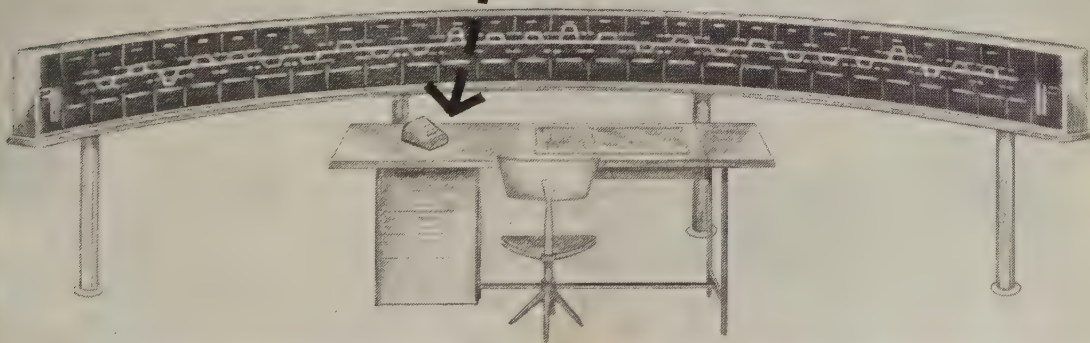
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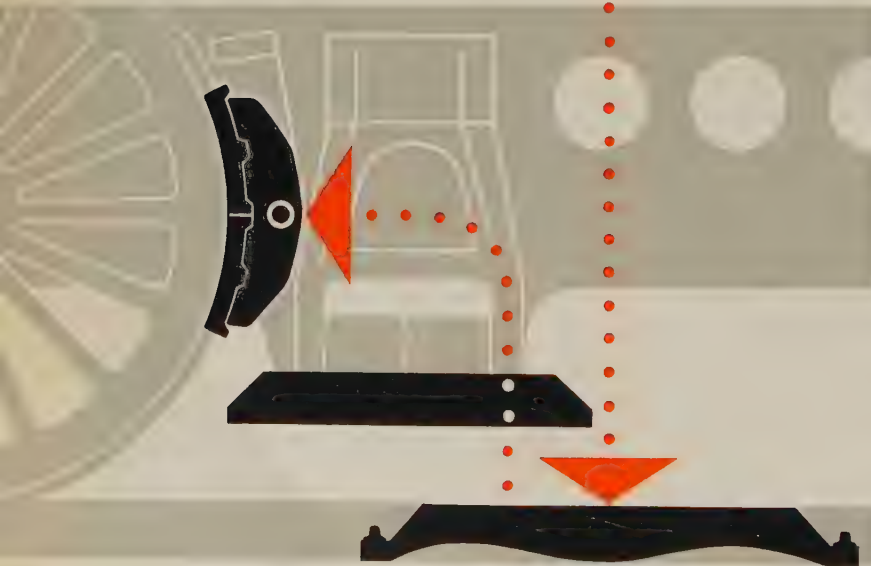
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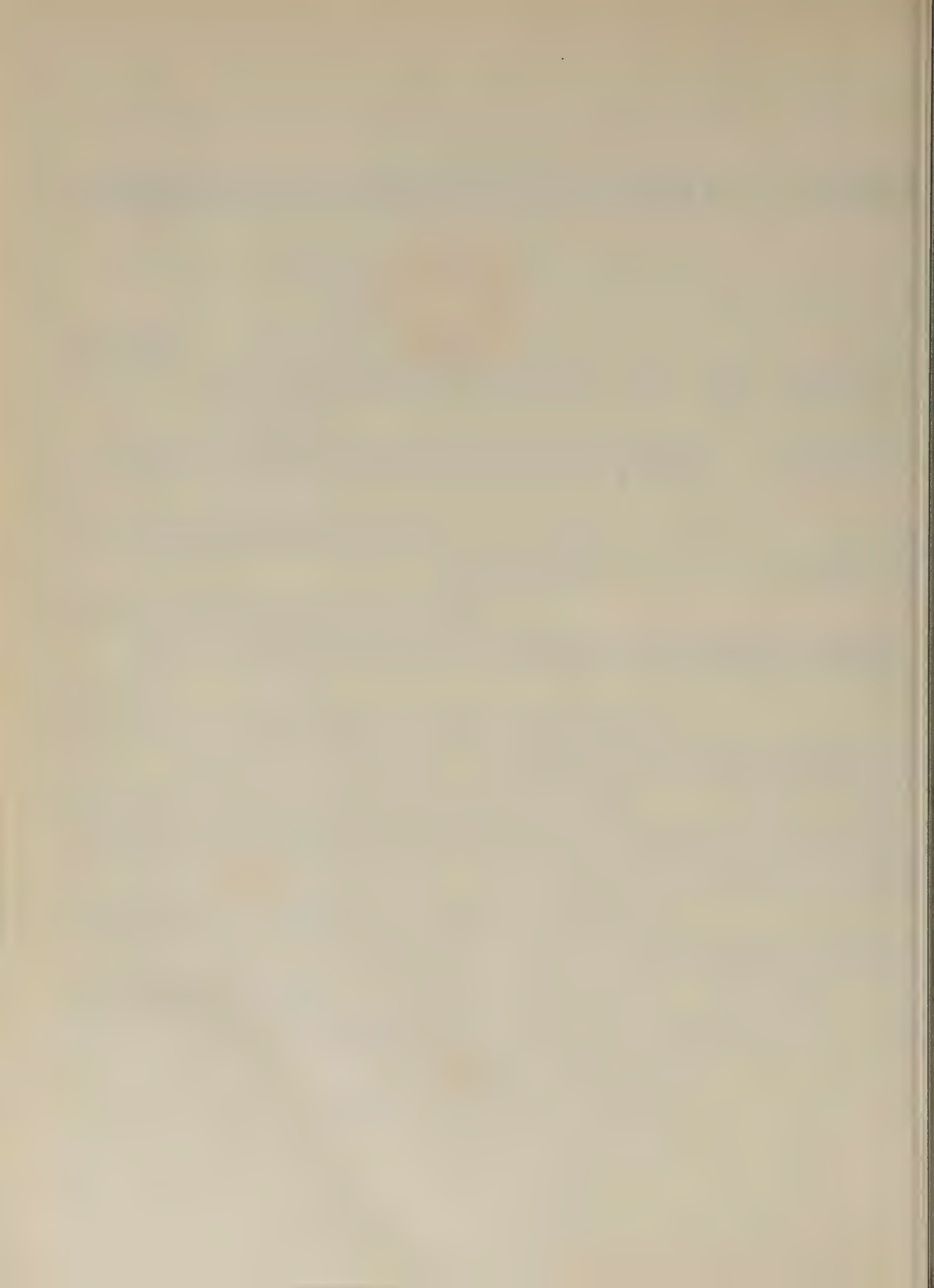
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BULLETIN
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[625 .253]

Factors in the development of an electro-pneumatic compressed air railway brake,^(*)

by S. KELLER, Engineer, Zurich. (**)

(*Economie et Technique des Transports*. No. 115 (4-6), 1956.)

Foreword.

This article, which is illustrated by six diagrams in five colours, is divided into three parts:

I. *Scope for an electrically operated brake;*

II. *Remote control of brake application and release;*

III. *Choice of an electro-pneumatic brake.*

The third part, which is much the longest, is followed by a general note on the conclusions.

I. — Scope for an electrically operated brake.

Modern distributors for compressed air railway brakes allow perfectly smooth driving — as regards the technical aspects of braking and from all other points of view — either on short multi-unit sets, passenger trains of up to fifteen 4-axled bogie

coaches or even of freight trains of up to 200 axles.

Operating requirements are largely met as regards the provision of minimum braked running and low buffer reaction during rapid braking and have a finely graduated brake application and release. In practice, difficulties are met only on local or express passenger trains with more than twenty 4-axled coaches with a high consumption of compressed air; these difficulties concern rapid brake releasing which is often required after a heavy application. It is true that protection against overload in modern brake systems has been improved to such an extent that one can obtain, by means of long-stroke refilling arrangements, relatively short release times at the end of the train; even after the maximum brake applications which are inevitable to avoid passing a warning signal when running at high speed. Unfortunately, these advantages are not available for long when working international trains because it is frequently the case

(*) Translation from German.

(**) Mr. S. KELLER, an engineer specialising in railway brakes, has previously contributed to « *Economie et Technique des Transports* » and we may recall his article in Nos. 4-6 (1954), on « Recent progress with compressed air brakes », pp. 53-56, 15 figures, three of these constituting 5 detailed diagrams in five colours. Another article by the same author appeared in Nos. 11-12 (1949), on « The Oerlikon brake for main line railways », 3 pages, 3 figures.

that coaches fitted with old type brakes are introduced into the make-up of the train.

An electric or electro-pneumatic brake undoubtedly has value only for long and heavy passenger trains or for fast freight trains.

II. — Remote control of brake application and release.

It is possible that in future railway traffic, one may be able to operate from outside — by means of electronic control, for example — both motors and brakes by regulating the brake to limit speed or to bring to a stop. It is obviously desirable that the remote control impulse should be transmitted with as little delay as possible to the control system, in our case to the brake. This condition would be fulfilled in the case of a electrically operated brake acting simultaneously on all vehicles of a train. On the other hand, if use were made of an electro-pneumatic brake instead of a purely electric one, there is a certain delay in the transmission of the impulse because of the time necessary for filling the brake cylinders and the durations of the brake release. Without taking account of the fact that acceleration of a heavy train lasts for a relatively long time, it is not desirable, for reasons of passenger comfort, to use the brake for acceleration or deceleration which would have disagreeable effects on the train.

Whilst it is therefore necessary in any case to accept some measure of delay in the transmission of the control impulses, one can, in principle, also control each train unit — solely and accurately — by remote impulse, by means of a suitable electro-pneumatic relay, located on the locomotive; particularly as the compressed air brake of the train concerned may be supplied pneumatically by the locomotive, in accordance with the considerations noted in I. In this case, too, electric control of the train brake itself becomes necessary only when the train consumes more than a specified amount of air during brake release.

III. — Choice of an electro-pneumatic brake system.

Since it is undoubtedly possible to fit a uniform brake, electrically operated in a limited time, to international vehicles of all European Railways, it is inevitable that the choice should be electro-pneumatic control, allowing each Railway Administration to retain its own system of pneumatic brake, such as is used at present. This refers not only to brakes on trailer vehicles but also to equipment on the locomotive, in view of the control of pressure in the main train pipe. It can be accepted, *a priori*, that shortly, and in accordance with the decision of the U. I. C. (*) all coaches working in international services will be fitted with a graduated brake release. Electro-pneumatic control, in accordance with the diagram in figure 1, fulfils this requirement completely. The pneumatic operation remains unchanged whilst the second pipe — previously used for direct braking — now serves as a feed pipe. The additional equipment of each coach simply comprises two electro-pneumatic valves, one of which exhausts the train pipe whilst the other fills the feed pipe. On the locomotive it is not necessary, in principle, to have a supplementary electro-pneumatic valve for opening the drain valves when there is a difference in pressure in the control reservoir of the driver's valve compared with the train pipe and also for opening the feed valves to the coaches when releasing the brake. This system is particularly advantageous because of the automatic return by the train pipe, since by this fact a uniform distribution of brake effort on all vehicles of the entire train is ensured. The supplementary electro-pneumatic equipment on the locomotive should also comprise a device for preventing re-feeding by the electric control of the train pipe during emergency braking or in the event of drawgear failure.

Apart from the advantage of a general international use of this type of control,

(*) International Union of Railways.

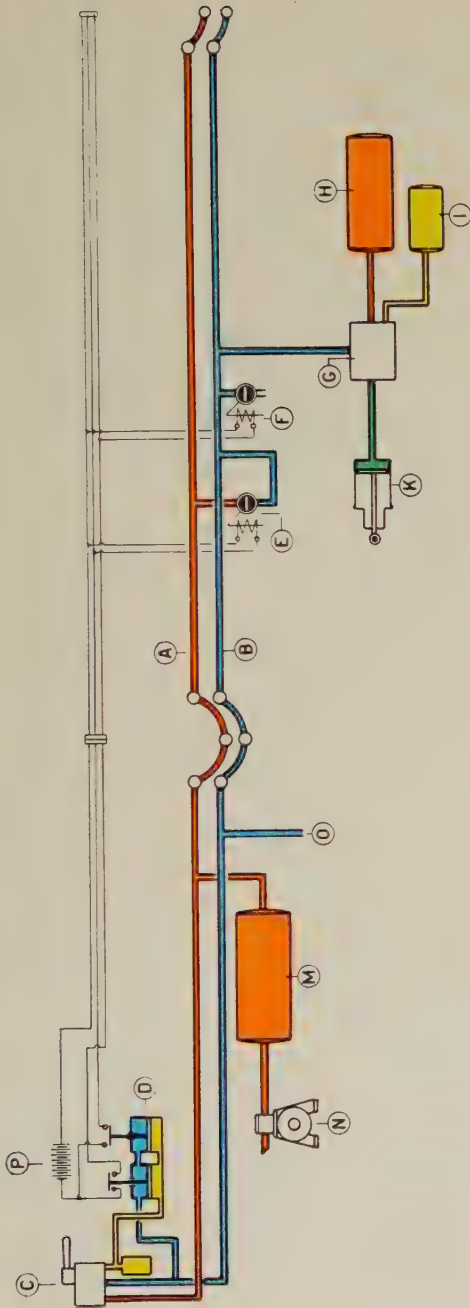


Fig. 1. — Ordinary automatic brake of no special type. Use of the former direct brake pipe for feeding an electrically-controlled brake. The control of pressure in the train pipe is done electrically through two electro-valves to each coach (admission and exhaust).

Explanations: letters indicating the component parts (figs 1 to 6).

- | | | | | | |
|---|---|--------------------------------------|---|---|---|
| A | = | Feed pipe. | M | = | Main reservoir. |
| B | = | Train pipe. | O | = | To locomotive brake. |
| C | = | Driver's valve for automatic brake. | P | = | Battery. |
| D | = | Electro-pneumatic control equipment. | Q | = | Driver's valve for electro-pneumatic brake. |
| E | = | Electro-valve for brake release. | R | = | Pilot cylinder. |
| F | = | Electro-valve for brake application. | S | = | Distributor with restrictor for maximum pressure. |
| G | = | Distributor. | T | = | Double non-return valve. |
| H | = | Auxiliary reservoir. | U | = | Non-return valve. |
| I | = | Control reservoir. | V | = | Electric contact, closed in running. |
| K | = | Brake cylinder. | X | = | Rheostatic regulator. |
| | | | Y | = | Electro-pneumatic regulating valve. |

Fig. 2. — Arrangement as in figure 1, but having auxiliary reservoir permanently supplied through a check valve. Restrictor to distributor to limit maximum pressure in the brake cylinder.

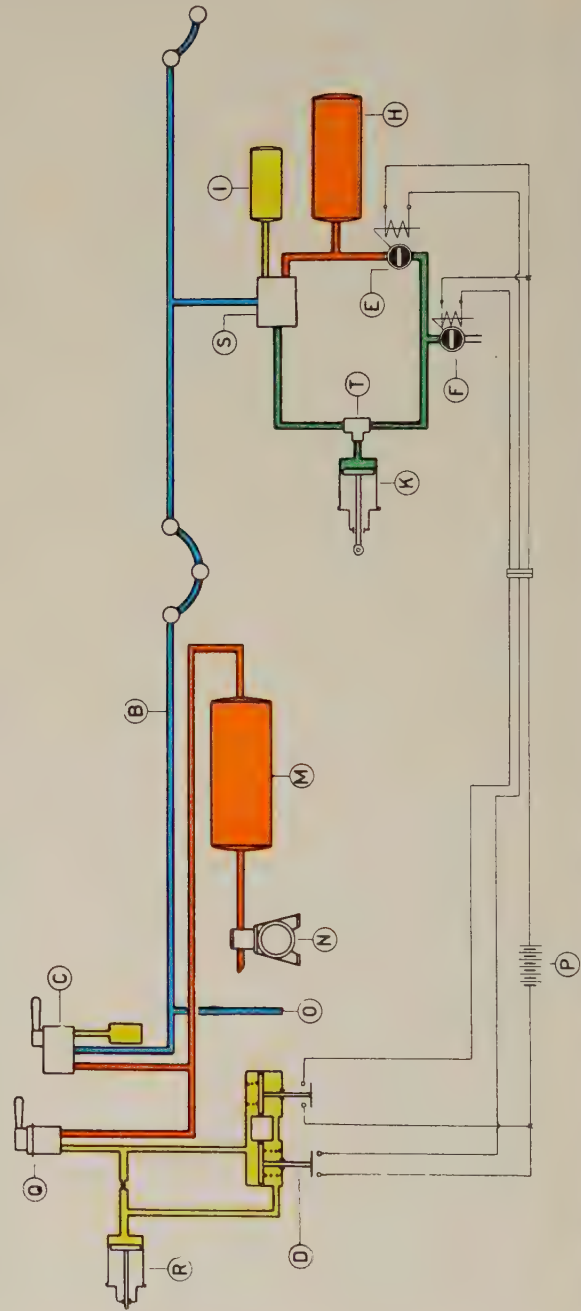
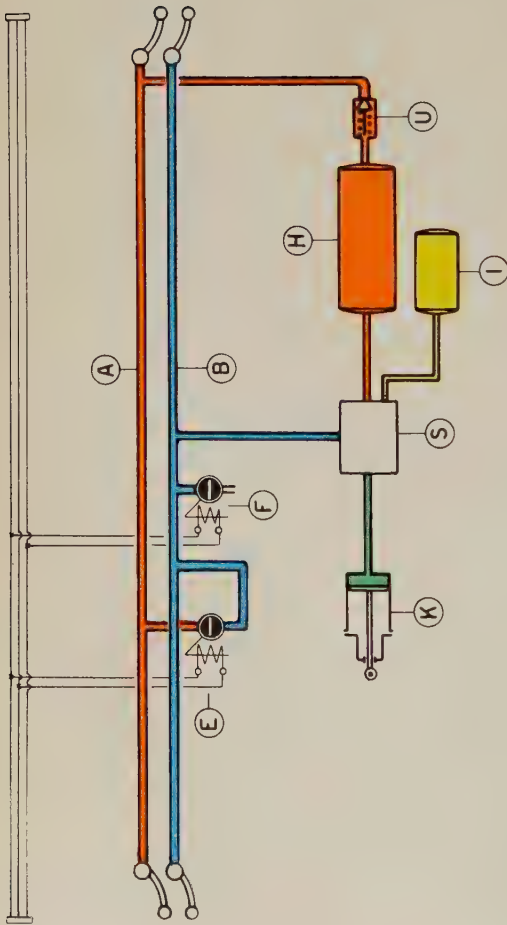


Fig. 3. — Automatic brake with single train pipe. Distributor with supplementary arrangements for limiting maximum pressure in the brake cylinder.

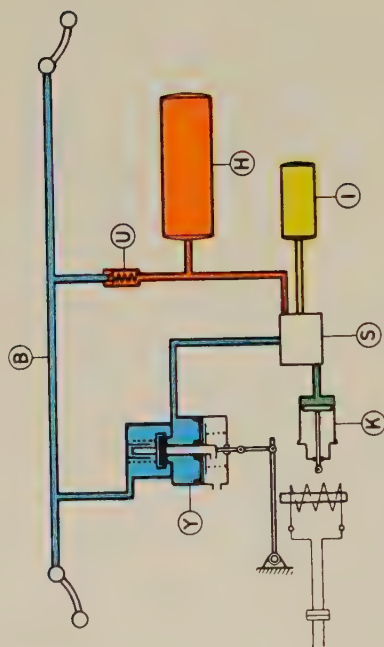


Fig. 6. — Automatic brake with single train pipe. Distributor with supplementary arrangements to restrict maximum pressure in cylinder. Permanent connection between train pipe and auxiliary reservoir, through non-return check valve. Electric control with servo-pressure regulator, electro-magnetic, between train pipe and brake distributor.

three other equally important points may be mentioned, as follows:

a) all losses of pressure in the brake cylinder and the auxiliary reservoir which is connected to it, as well as in the train pipe which refills it are automatically compensated;

b) if, on one or other of the coaches the electric control is defective, the pressure in the train pipe is still adjusted with sufficient speed by the electro-valves of the adjacent coaches;

c) if, for any reason, the electric control becomes a complete failure, the pneumatic fitting alone continues to operate normally. Safety of operation is thus ensured in a simple and, it may be claimed, an ideal way.

The diagram of pneumatic connections as in fig. 2 reveals another possibility. The electrical control in this diagram is the same as in fig. 1. The auxiliary air reservoir is however also connected permanently to the feed pipe through a non-return valve. This arrangement has the advantage during brake release it is not necessary to take air from the feed pipe to refill the auxiliary reservoir, the latter being continuously filled during braking through the non-return valve. This method would thus be suitable for very long trains, but it has the following serious defects:

(a) it is applicable only to those arrangements where the automatic brake distributor system — in the « off » position — prevents a re-feeding of the main pipe;

(b) as the pressure in the auxiliary reservoir can go up to 10 atmospheres according to the pressure in the feed pipe, it is necessary to provide a device for limiting the maximum pressure, during emergency brake applications, in the brake cylinders. This restriction of maximum pressure however, is provided only in a few automatic compressed air brakes (Drollshammer, Oerlikon USt, Knorr KE). Some European railway administrations would therefore be compelled to equip their automatic compressed air brakes with an additional device.

Another possible control arrangement is shown in the diagram of fig. 3. This at first sight appears attractive because only one compressed air pipe is required along the train, that is the train pipe. The brake cylinder is fed by the distributor during normal brake operation by compressed air. For electrical brake operation an electro-valve is inserted between the auxiliary air reservoir and the brake cylinder, allowing the compressed air to enter the brake cylinder directly from this reservoir. A second electro-valve is provided for direct discharge of air from the brake cylinder. The disadvantages of this method are:

(a) whilst air is being taken from the auxiliary reservoir, the latter is fed from the train pipe; this may cause a momentary drop of pressure in the latter, which then operates the accelerator of the normal distributor. On all types of distributor where the accelerator is actuated directly by the difference in pressure between the train pipe and the control reservoir, the accelerator would then act in respect of each electrically applied brake. It would consequently only be possible to combine this electrical system with accelerators which operate following a difference in pressure between the air in the auxiliary reservoir and that in the train pipe, for example, the older Westinghouse & Knorr distributors, the Oerlikon-USt distributor and the Westinghouse E 2 a. Even the most recent Oerlikon distributors, the ESt 3 d and ESt 4 d are suitable in this respect in view of their special design for blocking the control reservoir. All other new distributors with a sensitive accelerator, such as the Knorr-KE, Charmilles and Dako would have to have a supplementary screw — operated by the pressure of the brake cylinder — for the accelerator which would then operate only on the first application of the brake and would remain blocked at all other stages of braking;

(b) this single pipe system does not comprise automatic return to ensure that, when the brake cylinder pressure, adjusted from the locomotive, is reached, the admission

electro-valves on the coaches will then be closed. It would thus be necessary on the locomotive to refill a pilot reservoir from a second manometric cock. The refilling periods of the brake cylinders of all coaches would have to be equal and correspond exactly to that of the pilot reservoir. In addition, the curve of rising pressure, during the first stage of preliminary advance of the piston, in the pilot reservoir and in the brake cylinders of all coaches, would have to match exactly. If this were not so, it could — particularly with short filling periods for brake cylinders and short release times, even of about 3 seconds — produce very different pressures in the brake cylinders of the various vehicles;

(c) this system does not provide for the automatic restoration of pressure in the brake cylinders. Since, in service, there is always a large proportion of brake cylinders which are not air-tight and consequently cause varying losses, it could happen that when running on a down gradient there would be practically no pressure in certain cylinders. The driver would be aware of the excessive speed and would automatically make a supplementary brake application which would cause an overload of the brakes on the coaches where the cylinders were air-tight;

(d) the auxiliary air reservoir is continuously re-filled — when using the electro-pneumatic brake — at a pressure of 5 kg/cm² and it would therefore be necessary to provide a restrictor for the cylinder pressure, which in the case of a « high speed » brake with two stages set according to speed would be even more complicated.

In view of all these considerations, it appears that the single pipe system, which as already mentioned is at first sight very attractive, involves major complications and could in no case be combined with the present brake system of each railway administration. An improvement could be obtained by the introduction of a recoil device connected to all the brake cylinders of the train, i.e. through the second train pipe. However, it would then be necessary to feed, apart from the brake

cylinders, this pipe also, which is obviously not desirable. At the same time, the electro-pneumatic brake does in this way automatically feed and distribute the brake effort through the train. The restricted operation of the normal compressed air brake is not assured if the electric brake fails as this would need the addition of another valve with pilot reservoir.

The diagram in fig. 4 shows a single pipe arrangement in which the brake electro-valves act on a small addition of air introduced between the train pipe and the normal distributor of each vehicle. In this case also it would in the absence of a return pipe, be necessary to have a special pilot reservoir on the locomotive with the same drainage and refilling characteristics as for the amounts provided for the distributors on the coaches. Then, however, the difficulties compared with the diagram in fig. 3 would be even greater, because the fluctuations of pressure in the brake cylinders, in proportion to that in the chamber of the train pipe, would be about three times greater. As the auxiliary air reservoir would be continuously refilled from the train pipe, it would be necessary to limit the maximum pressure in the brake cylinders. Pressure drops following losses in the brake cylinders are compensated whilst losses of pressure in the train pipe chamber from the distributor and the reservoir connected to it are not compensated; this may result either in large fluctuations of pressure in the cylinders or in differences from coach to coach.

Contrary to the arrangements shewn in figs. 1 to 4, which provide for a brake electro-valve and a second release electro-valve, the diagram in fig. 5 shows an electromagnetic pressure regulator for each coach. This arrangement is the closest in principle to the usual type of distributor with graduated application and release for compressed air railway brakes and cannot be used as it is for long trains. Whilst electro-pneumatic-valves, both for admission and exhaust of compressed air, can be made without change for the arrangements shown in figs. 1 to 4 — even when the service voltage is only half the nominal — the

pressure created in the brake cylinders for a regulator valve as in fig. 5, would be proportionate to the voltage applied to the terminals. The brake effort would then be distributed irregularly over the length of the train, independently of the fact that this would be on the principle of the current at rest or at work. To keep as low as possible the drop in voltage on which it depends, there are — independently of the more complicated electrical connections (for example, in combination with the coach battery), there are the following possibilities:

1) as large a section as possible for the electrical control cable along the train;

2) application of a rather higher control voltage;

3) use of electro-magnetic components for regulating the pressure, with a current tapping as low as possible on the vehicles.

With regard to international standardisation, the control current can hardly be more than 110 V D.C. The current consumption of the electro-magnetic control equipment on the coaches depends largely on the control efforts required and the sizes of the valve cross-sections respectively. To keep the power needed by such fittings, and consequently the voltage drop, as low as possible, it is the aim to provide them for auxiliary current only (servo-control). Fig. 6 shows an example of this. Here too there is only one compressed air pipe along the train, that is, one train pipe; similar to fig. 4, when using the electro-pneumatic brake, the normal distribution is separate from the train pipe. It is then necessary to supervise only the pressure in the relatively small chambers of the distributor. It thus becomes possible to keep the control electro-valve small, that is, to limit its consumption of energy. This system has the advantage that it acts on the pressure of the train pipe in the control chambers of the distributor itself; any known compressed air brake can then be used either in its normal form or in combination with supplementary equipment pneumatically controlled and effecting either express braking,

dependent on speed, or automatic braking depending on load. The disadvantages are as follows:

(a) need to use a restrictor to limit the maximum pressure in the brake cylinders since the auxiliary compressed air reservoir is continuously refilled at the train pipe pressure;

(b) blockage of the accelerator in the distributor as otherwise the demand for air when actuating the brake, becomes much too great.

It is obviously also desirable to use the control voltage only to influence an electronic amplifier which in turn controls an electro-magnetic regulator valve fed by the coach battery. This avoids practically any voltage drop in the control cable. If, for example, the regulator valve voltage is determined — for basic brake application — at half the normal battery voltage, any exhaustion is precluded.

The construction of a regulator electro-valve working uniformly on all coaches constitutes in itself a fresh problem.

Conclusions.

The solutions indicated in this article do not exhaust the possibilities of combining a compressed air brake with electric control. The purpose of these comments is rather to show the conditions in which an electro-pneumatic brake can be considered suitable in future railway operation, and the conditions in which it is not necessary. In addition, it appears of the greatest importance that such electro-pneumatic control should be adopted internationally to allow combination without alteration of all known compressed air brakes with a minimum expenditure on supplementary fittings for coaches and locomotives. Any solution which can be realised only with one or other of the known brake systems should be discounted from the start. A universal solution which can be generally used and fulfilling every safety requirement in operation is that shown in fig. 1. The second compressed air pipe, used so far for the direct brake, can be

used without change as a feed pipe, especially as the « U. I. C. » has officially decided to eliminate direct braking.

The problem of a possible remote control of brake application and release would, in the interest of a standard method of remote control, have to be examined on an international basis. Moreover, the transmission of control impulses — in the general framework of the electro-pneumatic system of the locomotive — can be achieved in various ways. The electro-pneumatic

brake system of the train and the methods of remote control are very closely connected. For this reason, too, it is imperative that a decision should be made in good time regarding the preparation of general directives on an international basis.

The S. N. C. F. has already had in hand for some time systematic trials with locomotives and complete trains in order to investigate the application of various systems of electro-pneumatic brakes and methods of remote control.

New bridge on the Main near Stockstadt,

by Kurt NETTELBECK, Engineer, Frankfurt-on-Main.

(Eisenbahntechnische Rundschau, No. 5, May 1956.)

For the construction of a bridge demolished by blasting, modern steel construction methods were used, and a design was chosen which is not only remarkably attractive and clear but also unique for a railway bridge.

The double track bridge of the former Hessian Ludwig Railway opened to traffic in 1858, was built as an arched bridge of red Main sandstone (fig. 1). It crossed

by Mainz-Bischofsheim and the right bank of the Rhine connected the northern industrial region of Bavaria with the Nuremberg and Rhinish regions, avoid-

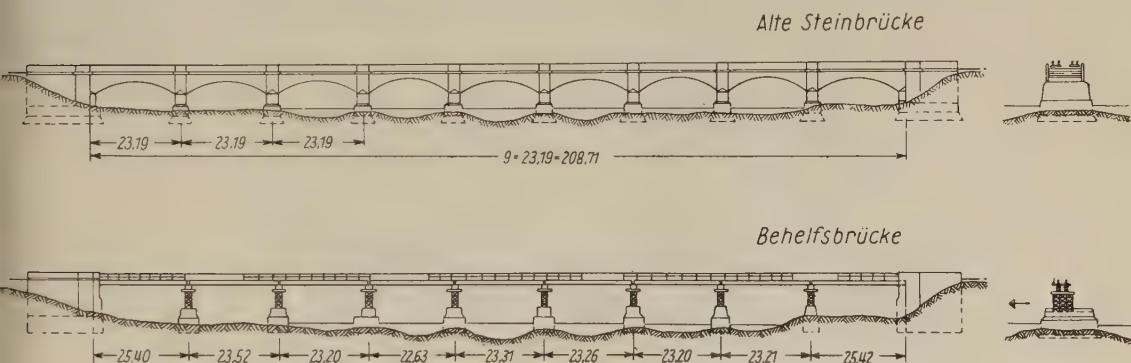


Fig. 1 (above). — Old stone bridge (1858-1945).

Fig. 2 (below). — Provisional bridge (1945-1955).

the valley of the Main in five identical arches of 20 m ($65' 7\frac{3}{8}''$) span and its total length was 208 m ($682' 5''$). Two of these nine openings in the middle of the river were used as navigable passages for ascent and descent respectively; they were quite adequate for the needs of the traffic on the Main, which was only later canalised.

The first bridge was destroyed during the retreat on the 24th March 1945. This broke an important railway line, which,

ing Frankfurt. Although the bridge had been in service nearly a century it had carried without reinforcement a heavily increased traffic and loads several times greater. Soundings of the piles showed few defects, caused only by the explosions. It can be assumed that the masonry bridge would still have been capable, without major maintenance works, of continuing in service for many years.

After the explosion, there remained only the bases of the piles and abutments.

In view of the importance of the railway for German internal traffic and because of the absence of any other practicable Main crossing, units of American engineers in 1945 constructed a provisional

man freight trains (fig. 2). The scaffolding was unprotected and could not have resisted a flood, much less drifting ice. When the line was taken over again by the Deutsche Bundesbahn in 1946, the

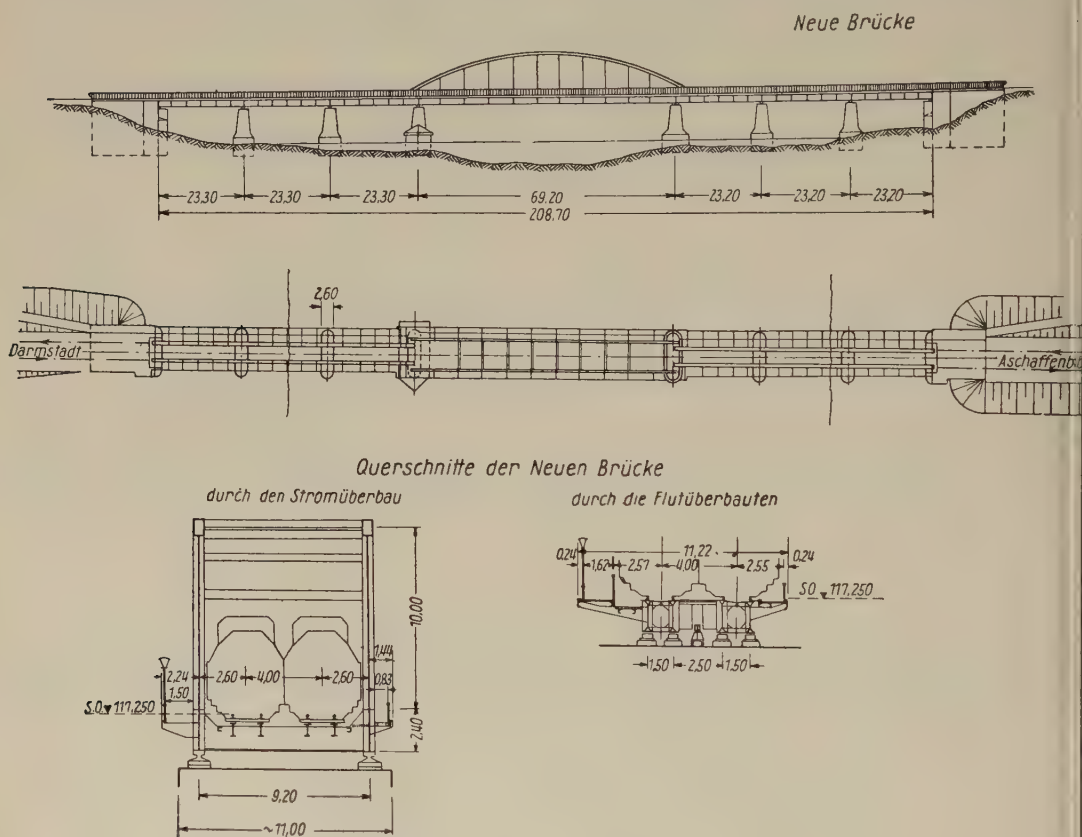


Fig. 3. — New bridge over the Main. Elevation, plan and section.

N. B. — Querschnitte der Neuen Brücke = sections of the new bridge. — Durch den Stromüberbau = through the central bridge. — Durch die Flutüberbauten = through the approach viaducts.

single track bridge on the remaining piles and abutments. The piles were cut down to the same height, raised by metal scaffolding and the superstructure formed by forged beams carrying the track. For a service which was still largely a war-time one, the provisional bridge was at first sufficient, because it was mainly used by military trains, with a few Ger-

bases of the piles were therefore surrounded by reinforced concrete up to high water level. The breakwaters of the piles in the current were also fitted with icebreakers.

Today, the bridge is passing 120 freight trains as well as 24 local and 12 semi-express passenger trains. For such traffic, the single-track bottleneck with its 10 km

(6.2 m.p.h.)/h speed restriction, had become unduly restrictive and needed replacing by a new bridge. After several proposals, the Frankfurt area management decided on the construction of a pre-welded steel bridge with all joints and connections rivetted on the site. Four

continuous single-track box beams were used, with a high resistance to bending and torsion, as approach viaducts and above the river itself, a double track Langer beam bridge (fig. 3).

The arch beam itself is an all-welded box type of Martin-Siemens St 37 steel;

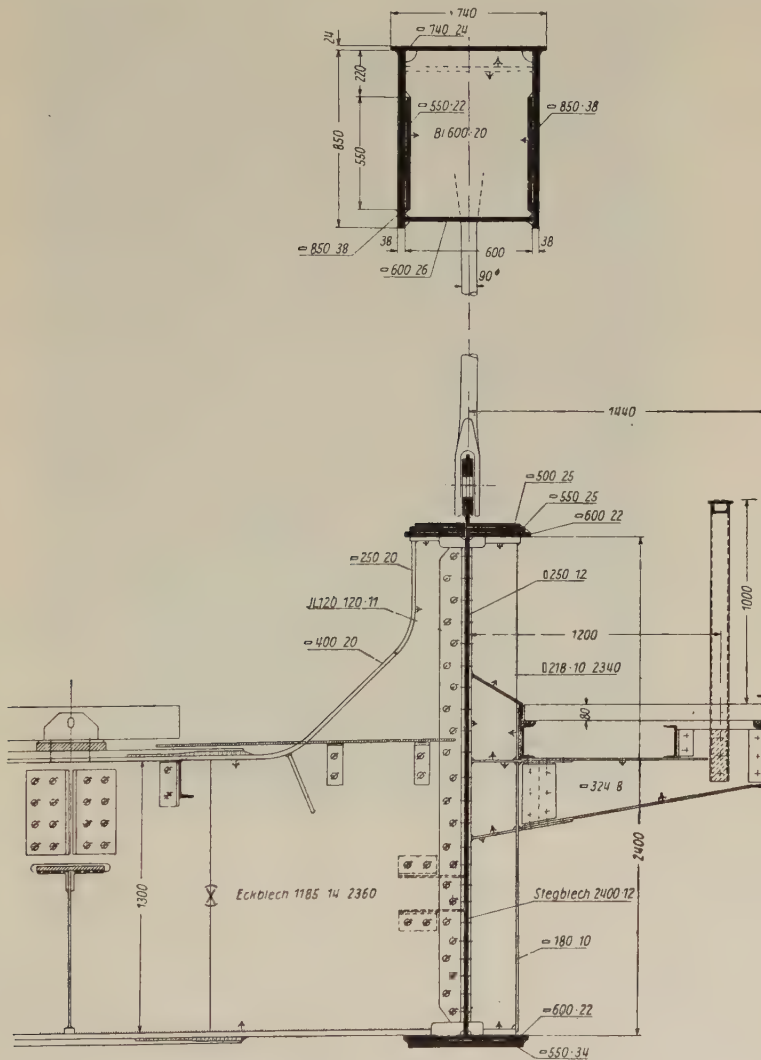
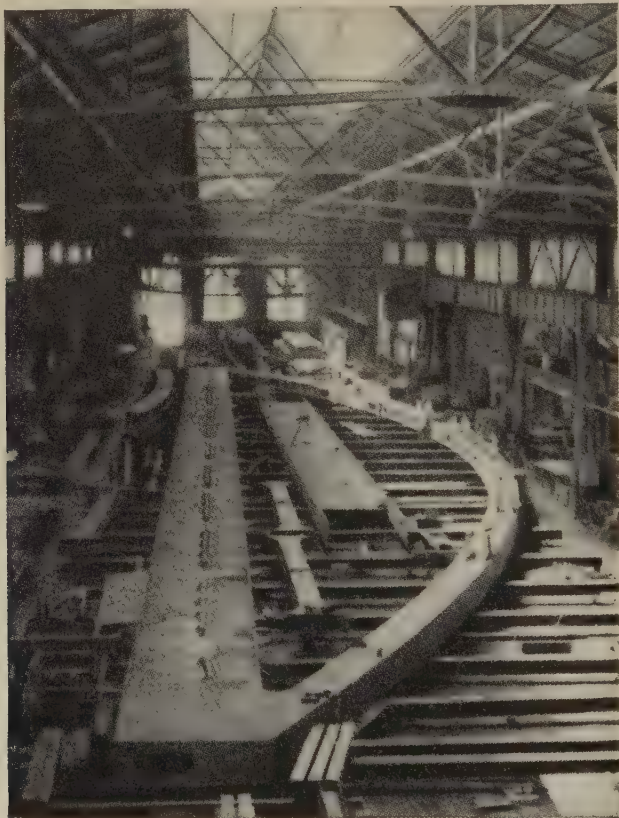


Fig. 4. — Section of arch and stiffener beam.

N. B. — Eckblech = gusset. — Stegblech = web.

the stiffener beam is I section of welded Martin-Siemens St 52 steel. It was not economical to use St 52 steel for the arch because its high resistance to compression would not have been fully utilised, the

shops (figs. 5 and 6). After completion of the piles, the upstream line of beams for the access viaducts were laid, the provisional bridge having been laid on the downstream side. The central super-



(Werkfoto Eisenwerke Kaiserslautern.)

Fig. 5. — Main beam of central bridge during fitting.

sizes of the section being governed by local stresses. Figure 4 shows a section of the arch and stiffener. The suspension bars are of round forged steel bars.

In July 1953, work commenced on the restoration of the piles and preparation of the steel superstructure in the work-

structure and scaffolding was put into position on the 26th September 1955, after dismantling the provisional bridge. The Aschaffenburg-Darmstadt line was thus opened to traffic. The superstructures of the access viaducts for the Aschaffenburg-Darmstadt line were next

put into place. The complete provisional bridge with track and pylons on the piles was dismantled with the aid of a special rail-mounted crane, which also served for the erection without scaffolding of the whole of the superstructure for the access viaducts. On these, the rails were laid directly with rubber pads to ease the

regards the continuous superstructures of the approach viaducts, this result could easily have been achieved because each pile was loaded only on the longitudinal centre line. On the other hand, on the central piles the bearing of the superstructures of the viaduct and the bridge, which were connected, could be set on



(Werkfoto Hilgers, A. G., Rheinbrohl.)

Fig. 6. — Box girder assembled in the workshop for approach viaduct superstructures.

dead weight on the ballast bed. On the bridge itself, the tracks were laid on longitudinals.

The transition from the double track central bridge and the access viaduct superstructure to a single track called for special care because of staggering of the superstructure centres [central bridge 9.20 m (30' 2 1/4"); centres on the main outer beams of the viaduct superstructures 5.50 m (18' 3/4")] to ensure satisfactory stability. Furthermore, the piles had not been changed in width or length. As

the longitudinal centre of the pile only by offsetting the stay assembly of the bridge superstructure. Figure 7 shows the layout of the arrangement on the check pile. The decks of the access viaducts rest on armoured steel plate. On the central bridge over the river, with a load of 600 t, special multiple ball bearings have been designed with longitudinal, transverse and universal mobility (fig. 8).

The caissons of the stiffening arch and the upper windbracing are of welded steel plate and are not accessible; the

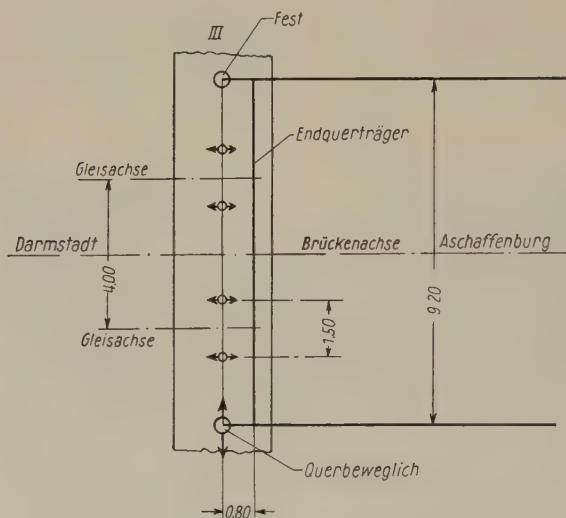
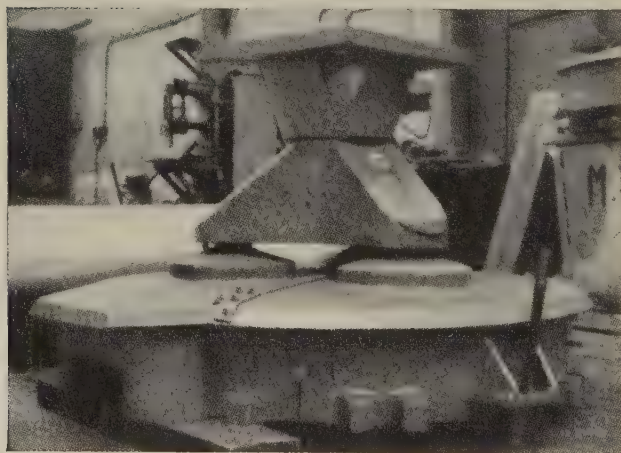


Fig. 7. — Arrangement of supports on check piles.

N. B. — Fest = fixed. — Querbeweglich = side movement. — Gleisachse = centre of track. — Brückenachse = centre of bridge. — Endquerträger = end stay.



(Werkfoto Hilgers, A. G., Rheinbrohl.)

Fig. 8. — Mobile multiple ball bearing, Schönhöfer universal movement type, for central bridge.

plates were derusted by hammer and brush before assembly and are not painted inside.

The box sections of the central bridge were welded and made airtight, even at

service to avoid the deposition of soot on fresh paintwork before it hardened.

Use was made of phthalic resin-based paint because often there are pin holes left by the residue of the powdered pyrites



Fig. 9. — View through central bridge.



Fig. 10. — View of the new construction.

the assembly joints. The box girders of the viaduct, which are accessible, could, after sand blasting, be given two priming and two finishing coats. Moreover, the bridge was painted before being put into

from nearby cellulose works which are driven onto the bridge by the wind in the form of dust clouds; it was thus necessary to avoid the risk of setting up a chemical combination which might be

dangerous to the surface of the paint, if there were a deposit on the steel during damp weather.

The new bridge over the Main has been in service with two tracks since the 1st December 1956. Despite its robust

construction, as shown by the dimensions in the table, it has an extraordinary appearance of lightness (figs. 9 and 10) which must be attributed mainly to the use, for the first time in a railway bridge, of round suspension bars between the main and arch beams.

TABLE : — Characteristics of the bridge.

	Old bridge	Provisional bridge	New bridge
Date of construction . .	1853-58 (destroyed 24/3/45)	Autumn 1945	July 1953 to December 1955
Spans	9 × 23 m	9 × 23 m	3 × 23 + 1 × 69.2 + 3 × 23
Navigable ways	2 × 20 m	2 × 20 m	1 × 36 m
Type of bridge	masonry arch	IP 100 rolled steel beams	centre : Langer steel beam access viaducts : metal box beams with high torsion and flexing resistance.
Construction materials .	Main sandstone	Thomas steel	bridge : arch, plating and wind- bracing : Martin S. St. 37 steel stiffener beam : Martin S. St. 52 steel. approach viaducts : Martin S. St. 37 steel.
Weight	—	—	bridge : 531 t; 3.84 t per m of track approach viaducts : 376 t; 1.40 t per m of track supports : 27 t
Classification	—	—	train-type S (1950)

Stone sawing machine to cut back tunnel vaults,

by M. ROUSSEL,

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(*Revue Générale des Chemins de fer*, September 1956).

In connection with the electrification of a railway line by means of overhead conductors, it is usually necessary to enlarge the clearance of a great number of overbridges and tunnels.

This may be done either by lowering the track, which is a long and costly operation calling for irksome traffic restrictions, or by cutting back the facing stones of the vault.

Prima facie, the latter operation appears to be economic in view of the fact that it only affects a small volume of masonry, and mainly because it does not call for permanent speed restrictions or single line workings. These are important advantages on a line which is in the course of electrification, and where the traffic problems are always difficult to solve.

Unfortunately, the cost of normal working methods, based on the use of picks and sledge hammers or pneumatic tools, increases very rapidly with the hardness of the material. On the other hand, the need to confine the trimming to a minimum thickness of stone material so as not to jeopardize the safety of the structure precludes the use of devices normally used for heavy demolition work and, in particular, the use of explosives.

With a view to choosing the method best suited for this kind of work, various tests have been carried out by the South-Eastern Region of the S.N.C.F. on the occasion of the electrification works in the tunnel of Champvans on the Dijon-

Dole line, which is being equipped for 1 500 V D.C.

This tunnel, which is 860 m (2 822 ft) long, is lined with sound masonry of coursed quarry stone (hard limestone from the quarries of Sampans in the Jura mountains) rough-cast with lime mortar. It was necessary to cut away the stonework at the vault springings to an average depth of 10 cm (4") over the whole length and over a width of about 1 m (3' 3").

It was found that very encouraging results could be achieved by sawing the facing stone, in the longitudinal direction, into narrow slices which could then be simply knocked out with a hammer tool of some kind.

After tests carried out in a quarry, a special machine akin to the sawing machines used for stone work was developed by « Entreprise Pascal », Grenoble, who were in charge of the works, in conjunction with « Etablissements Perrot et Aubertin », Beaune (Côte d'Or), machine manufacturers. The machine was taken into operation in May, 1955, and used at the end of 1955 and beginning of 1956 for the cutting of about 2 000 square metres (21 500 sq. ft) of stone material from the vault of the Champvans tunnel.

The machine consists essentially of the following parts (cf. fig. 1) :

— a cast iron trolley moving on two rails of 8 m (26' 3") length and 1 m

(3' 3") gauge, permitting a travel of about 6.50 m (21' 4");

— a cast iron platform mounted on the trolley, 2.50 m (8' 2") long and 0.75 m (2' 6") wide, able to slide sideways over a distance of 60 cm (2 ft);

— two vertical cylindric columns, integral with the platform and spaced at 1.50 m (4' 11") centres.

marble masons, carry a bronze rim with diamond grains ⁽²⁾. This rim is notched so as to facilitate the removal of the limestone spoil. The travel of the arm on the column (50 cm) and the turning of the headpiece permit a total vertical displacement of the disks by 1 m (3' 3"). The disks can be adjusted for sawing in any direction.

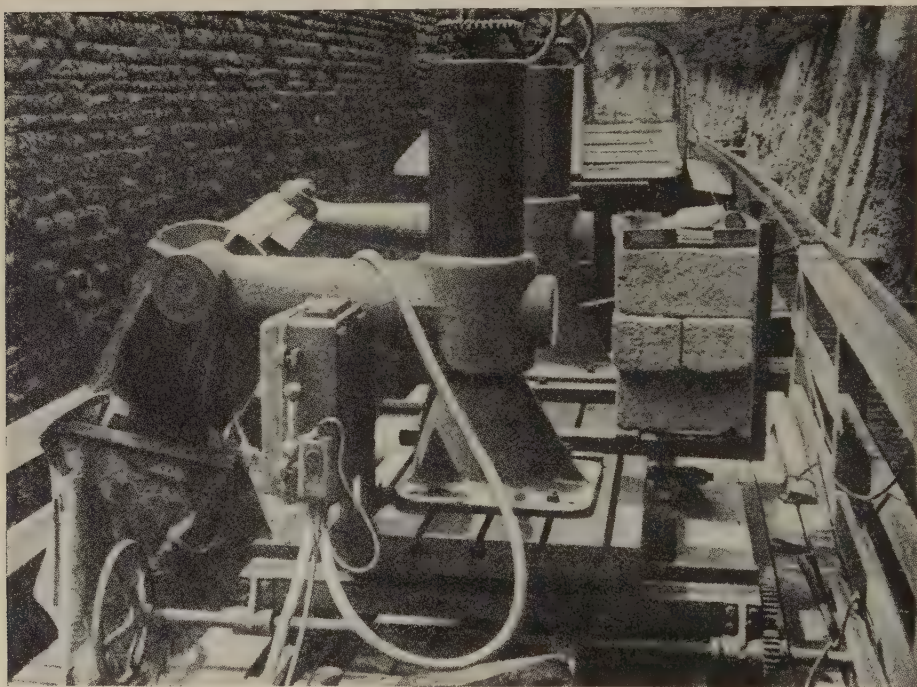


Fig. 1. — Complete view of stone sawing machine.

On one of these columns slides an arm (fig. 2) which supports a head piece with two parallel saw disks of about 60 cm (2 ft) diameter, 7 cm (2 3/4") apart ⁽¹⁾. These tools, rather like the saws used by

In addition, another slide permits the movement of the tools in their own plane so that they can be engaged and disengaged.

On the other column slides a similar arm which carries a 16 HP, 2 800 r.p.m.

⁽¹⁾ During the first tests, the machine carried only one saw disk. But experience showed that the use of two disks permitted a considerably higher output.

⁽²⁾ Originally, the disks were fitted with carborundum but this was found to wear too quickly.

electric motor. This arm can likewise be adjusted and can follow the movement of the pulley on the disk carrier which is operated by a protected V-belt drive.

The entire machinery is mounted on a scaffold installed on a platform wagon. A tender carries a compressor, with 3 HP electric motor, supplying pressure water through a system of ducts so that the

moved longitudinally over the whole travel of the trolley. Owing to the supplementary slide, the saws can be disengaged at any moment.

A strip of 1 m (3' 3") width is dealt with by applying two series of four passes: first the lower half over the whole length of the tunnel, and then the upper half after adjustment of the saw disk carrier.

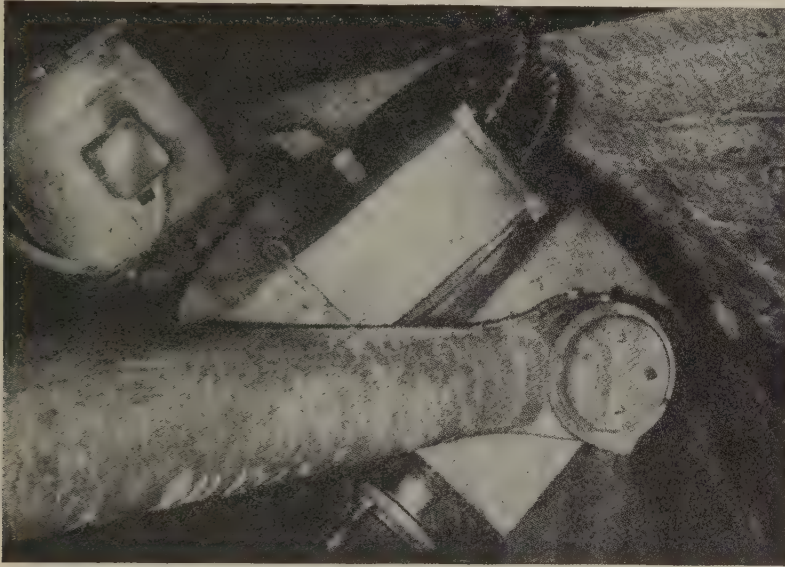


Fig. 2. — Close-up of saw disk carrier.

disks can work under a continuous jet of water.

After determining the zone and required depth of the cuts, the work consists of two phases:—sawing and demolition. These works can be carried out simultaneously as soon as the sawing has made a certain headway.

a) When sawing begins, the rotating disks are brought into contact with the soffit, in the direction normal to it, by making use of the possibilities of linear and rotary displacement inherent in the mechanism. The saw disks penetrate the masonry to the required depth and are

b) Because of the small distance between the two disks, it is easy to knock out the slices between them. The top slice is removed by means of a chisel and mason's hammer (fig. 3). The other slices can then be removed by means of the hammer alone. This work is carried out from working platforms mounted on platform wagons.

The surface of the remaining masonry generally shows a very satisfactory regularity. The few projections which it is still found necessary to remove after verification are cut out by hand.

The number of workmen can be so

chosen that the rate of progress at the two working sites is uniform. All the vehicles can therefore be made to form a single works train, consisting of:

- a power unit;
- a tender;
- a wagon with the saws;
- several platform wagons for the demolition work;
- a workshop wagon.

has very little influence on the rate of progress so that it is sometimes worth while cutting the stone deeper merely in order to facilitate the demolition work.

On the other hand, the rate of progress is only satisfactory in stonework of good quality.

One disk can, on an average, saw 1 200 linear metres (nearly 4 000 ft) of masonry, corresponding to a vault surface of 170 sq. metres (about 1 800 sq. ft).



Fig. 3. — Knocking down the first slice of stonework.

The team, directed by a foreman, comprises four men operating the machine and five to seven men knocking down the stone slices.

The progress of the saw disks, which governs the progress of the work, can be 6.50 m (21' 4"), corresponding to the travel of the trolley, in about 15 min, including the adjustments, for an average cutting depth of 8 to 10 cm (3 to 4").

It is noteworthy that the cutting depth which may be as great as 16 cm ($6\frac{1}{4}$ "),

The cost incurred by this item represents about a fifth of the total cost.

Water consumption is about 0.6 cubic metre (0.8 cubic yard) and electricity consumption about 4 kWh per square metre of surface cut back.

In the circumstances, the cost of the stone trimming operation alone amounts to about one-third of the cost of the same work if carried out by hand, and about two-thirds of the cost of the work if carried out by means of pneumatic hammers.

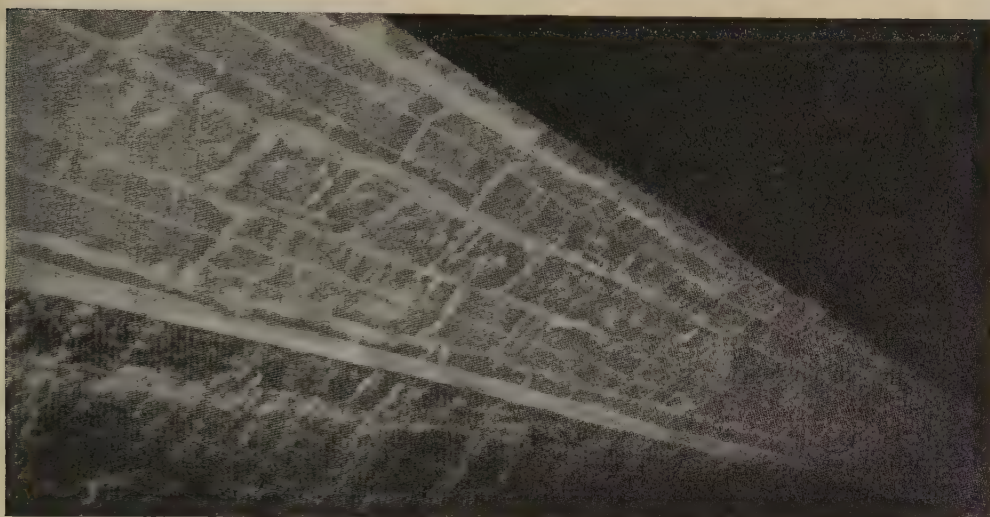


Fig. 4. — A strip of stonework after trimming.

For these reasons, the machine has also been used in the spring of 1956 in the two tunnels at Chagny which are 75 and 80 m (246 and 262 ft) long, where it was necessary to raise the permanent way and therefore to trim the whole of the vault. What was even more appreciated than the low cost was the high rate of progress due to which it was possible to limit the

duration of single-line working which was a great handicap on this section with particularly heavy traffic.

With the only proviso that an adequate source of electric power can be installed in the immediate vicinity of the site, the use of this stone sawing machine has therefore been found advantageous for this kind of work.

Packing technique for the benefit of transport.

The general laboratory for packings,

by M. VERLOT,

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(*Revue Générale des Chemins de fer*, September 1956.)

The *general laboratory for packings*, which was officially inaugurated on the 7th November 1955 in its new offices attached to Auteuil Station, 105, Boulevard Suchet in Paris, was inspired by the requirements of the new science of « good packing » in order to perfect this constantly.

The first steps were taken in 1949, when the S. N. C. F. and the manufacturers of packing materials, members of the Technical Society of the Packings Industry, opened in the disused station of Courcelles-Ceinture, 2, rue Alfred Roll in Paris, a laboratory intended especially to improve the packing of consignments.

The initiative of the S. N. C. F. was at that time essentially practical in its objectives, to the benefit moreover of its clients just as much as its own, to encourage the use of well defined types of packings and create for this purpose a tariff policy applicable only to goods packed in these quality packings, *approved* by the railway and given a guarantee seal.

This led the first laboratory to carry out studies to :

- a) ascertain what measures would avoid damage during transport;
- b) advise manufacturers and users;
- c) check the strength of packings sent to them for test;
- d) determine the best types of packings at the lowest cost by publishing in the form of « Technical Notes » their detailed characteristics.

The results obtained were so important

in the practical field of packing and transport that the idea of a laboratory with a more extensive programme was then born, the setting up of which would depend upon a much wider interprofessional agreement.

The qualified technicians of the S.N.C.F. and the Technical Society of the Packings Industry devoted themselves to the realisation of this agreement between 1951 and 1953, and succeeded in creating on the 6th July 1953 an Interprofessional Association, with no financial interest in the matter, governed by the law of the 1st July 1901, which was given the name of the *General Laboratory for Packings*.

According to its statutes the main objects of this Association are :

- 1) to put at the disposal of all transport undertakings, producers, packers, users of packings, and in general all those concerned with the packing, conditioning, display and handling of products of all kinds, a *central research and experimental organisation*;
- 2) to set up for this purpose one or several laboratories able to make all the necessary studies or trials of the most effective materials and methods of packing, and in particular to set up, run and develop a central research and experimental laboratory;
- 3) to cooperate on the technical plane with existing research offices, laboratories or organisations having the same object, and to train packing specialists;

4) to operate controls and give expert advice within the defined limits;

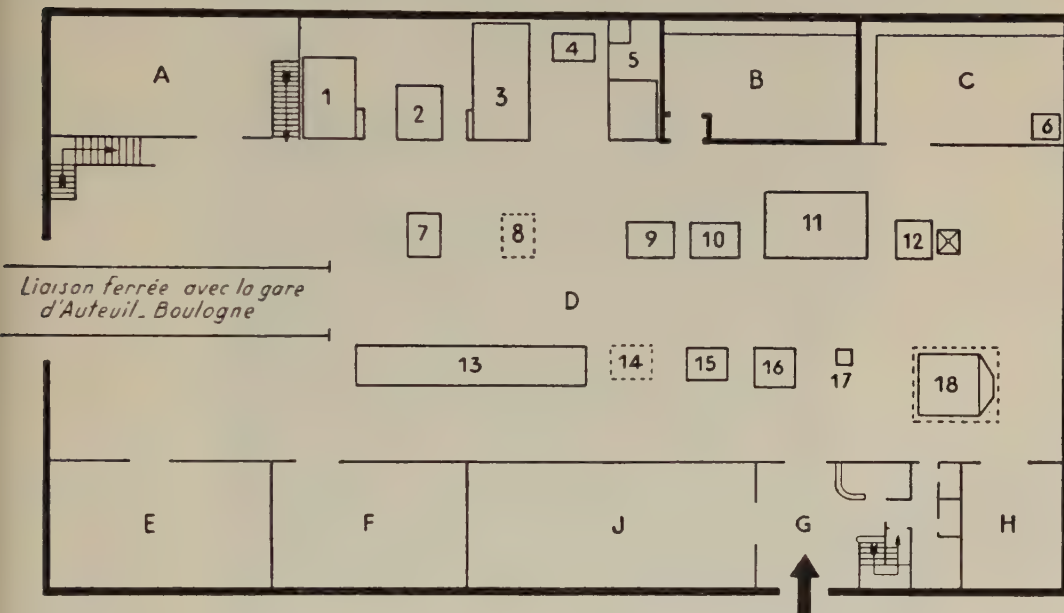
5) and in general to carry out all the work and investigations needed to favour progress in the field of packings in the widest sense, i.e. covering all the operations of packing properly so-called, the display, conditioning, protection, handling

the general interest of its character, began with some forty members; it now has some hundred.

These belong to four main categories :

1. — producers and processors of materials used for packings (wood, paper, carton, textiles, plastic materials, etc.);

2. — transporters and representatives of



- | | | |
|---|----------------------------------|-------------------------------------|
| 1. 15 m ³ hot-humid chamber. | 9. Automatic 500 kg scales. | A. Stores. |
| 2. 1 m ³ bunker (hot-cold-vacuum). | 10. Small drum. | B. Air conditioned laboratory. |
| 3. 15 m ³ cold chamber. | 11. Large drum. | C. Chemical laboratory. |
| 4. Saline fog bunker. | 12. Shock pendulum. | D. Central hall (mechanical tests). |
| 5. Immersion and pluviometric tanks. | 13. Inclined slope. | E. « Timber and metal » shop. |
| 6. 250 dm ³ «hot-humid» bunker. | 14. 6 t press. | F. « Carton » shop. |
| 7. Bracket. | 15. 3 t press. | G. Reception. |
| 8. Opening of sack chute. | 16. Large trapdoor. | H. Stores. |
| | 17. Small trapdoor. | J. Meeting hall. |
| | 18. Vibrating and shaking table. | |

Fig. 1. — Plan of the ground floor of the laboratory.

and transport. Achieved by private initiative with the effective help of the General Commissariat of Productivity and the French Association for the Increase of Productivity, and with the official encouragement of the Ministry of Industry and of Commerce, the new association, whose objects as listed above clearly define

activities connected with the actual transport (handling firms, insurance companies, professional packing organisations, etc.);

3. — research institutes and centres, etc.);

4. — users.

* * *

In practice, the General Laboratory for Packings, the only such body in France with an official character, covers more than 1200 m². Linked up with the railway and very accessible by road, it consists of (fig. 1) a very spacious hall for trials equipped with various installations, which as a whole make it possible to carry out under optimum conditions as regards technique and speed, all the trials in con-

- bracket for drop tests;
- inclined plane for buffer tests;
- two vertical presses, one of 3 t and the other of 10 t;
- large drop trapdoor;
- small drop trapdoor;
- Flat-Crush-Tester for measuring the flexibility of materials used in the manufacture of packings.

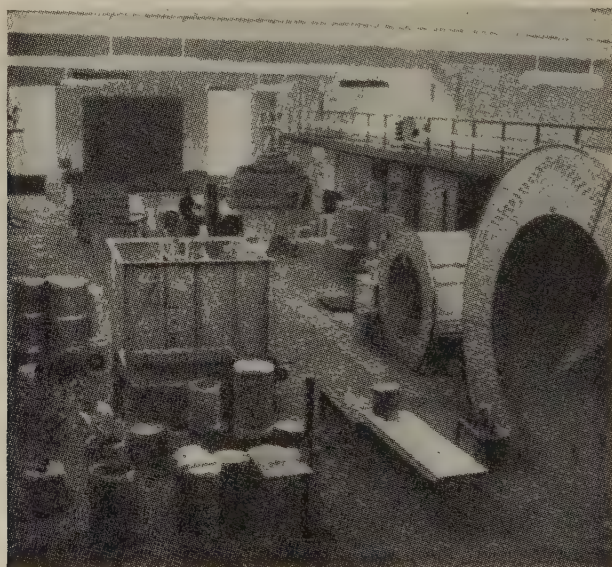


Fig. 2. — General view of the equipment used for testing made packings.

nection with the most varied types of packings.

These trials can be classified into four main groups.

I. *Tests of a mechanical type* for making which, the great hall of the laboratory has been equipped with the following :

- shock pendulum for testing bottles;
- large drum;
- small drum;
- 500 kg automatic weighing machine;
- drop table for sacks;

This equipment of the classical type (fig. 2) designed for certain well defined operations does not call for any special comment; it is used in particular to determine the following qualities of packings :

- a) its resistance to longitudinal shocks in the wagons, as well as vertical shocks in the lorries;
- b) its suitability for *stowing*, with satisfactory rigidity when stowed;
- c) its *stacking* possibilities;



Fig. 3. — General view of the rooms and bunkers used for climatic tests.

d) its resistance to shocks due to *dropping*.

In this series, a further set of equipment is being obtained, viz. the so-called oscillating and vibrating table, the combined shaking and vibrations of which, designed for useful loads of up to 3 t, will make it possible to judge how packings will stand up during transport to varying stresses or shocks of horizontal, lateral and vertical types or various combinations of these.

This equipment, space for which was reserved in the great hall as soon as the laboratory was projected, will be particularly useful for studying the criteria of samples of wooden packings, of the non-returnable type, used for fresh fruit and vegetables, the control methods of which are shortly to be decided in Geneva by the group of the European Economic Commission dealing with perishable goods.

II. *Trials of a climatic nature* are made



Fig. 4. — « All climates » 1 m³ bunker.

with very up-to-date equipment (fig. 3) consisting of the following apparatus and installations :

- large immersion tank;
- small immersion tank;
- trial area for artificial rain;
- saline fog bunker;
- cold chamber, 15 m³, which can be regulated from plus 20 to minus 40° C;

it possible to reproduce all the climatic conditions that could be met with anywhere in the world, on both land and sea. With the « hot-dry » chamber and the « hot-damp » chamber, each of 15 m³, in which the temperature can vary from plus 20 to plus 100° with relative humidity of 20 to 100 %, for example it is possible, without any manual intervention, to obtain for 10 h 40° C with 90 % relative

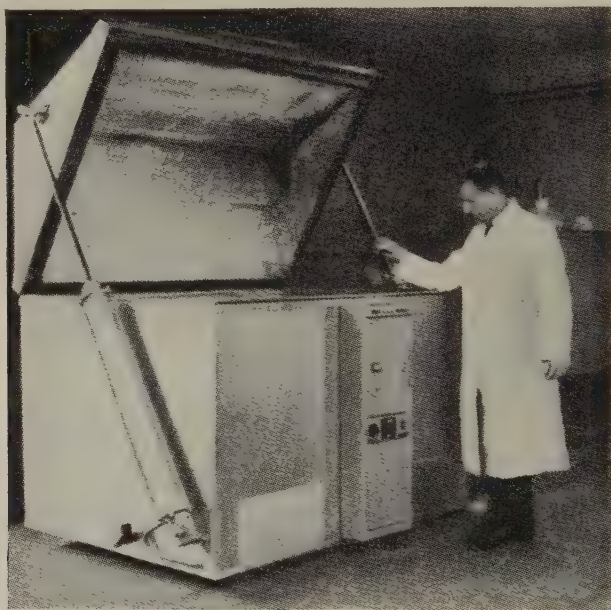


Fig. 5. — Saline fog bunker.

— « all climates » bunker, 1 m³ which can be regulated from minus 60 to plus 100° C and from 760 to 50 mm/Hg (fig. 4);

— humid chamber, 15 m³, which can be regulated from plus 20 to plus 100° C with variable hygrometry of the atmosphere at saturation at 100° C.

As M. Bourgeois, Chairman of the Laboratory, has already pointed out in a recent lecture to the Association of the Great French Ports, this equipment makes

humidity, then for 14 h 25° C with 90 % relative humidity for weeks on end : testing a packing under these conditions will determine exactly its resistance to a tropical climate.

Amongst this climatic equipment, the saline fog bunker deserves special mention, as it is quite original in conception and design.

This equipment, entirely of French manufacture (fig. 5) is in the form of a tank, the cover of which can be raised by

two pneumatic jacks. The arrangement of the heating resistances inserted in the walls makes it possible to homogenise completely the state of the air and the fog inside the tank, thus giving the maximum precision to the tests carried out therein.

- 3) the thickness of a protective covering;
- 4) the comparative resistance to corrosion of different materials and alloys;
- 5) noting galvanic effects;
- 6) the detection of free metal.

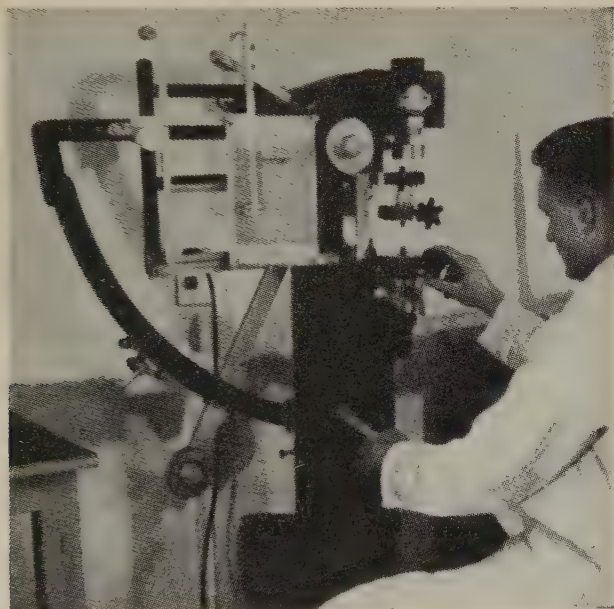


Fig. 6. — Resistance test using dynamometer.

What sort of tests are they? In general they are made with the object of submitting a material to the action of a corrosive atmosphere in order to determine its resistance thereto. It is a question therefore of comparing the resistance of this material to deterioration in the presence of a saline fog with its resistance under ordinary conditions of use.

The saline fog bunker makes it possible to determine :

- 1) the protection value of a metal or non-metallic covering;
- 2) the detection of gaps in the protective covering;

In carrying out the tests, different standards are used which vary according to the concentration of the vaporised saline solution and the temperature at which the test is carried out. This latter factor is of considerable importance and modifies very considerably the results obtained according to whether the tests are made at ambient temperature or at 35° C. The concentrations most commonly used are 3 % and 20 % of sodium chloride.

In general the tests last for 72 h. Naturally, this conventional period in no case makes it possible to determine how

many months or years the material under test can stand up to the action of maritime climates.

III. *Physical tests* take place in a laboratory specially arranged for the purpose with a climate of plus 20° C with 65 % hygrometry.

IV. *Chemical tests* are carried out in another laboratory equipped as follows :

- 250 dm³ capacity tank (permeability test);

- a tank for dehydration tests;
- 100 and 200° C ovens;
- precision scale which can be read off instantaneously;

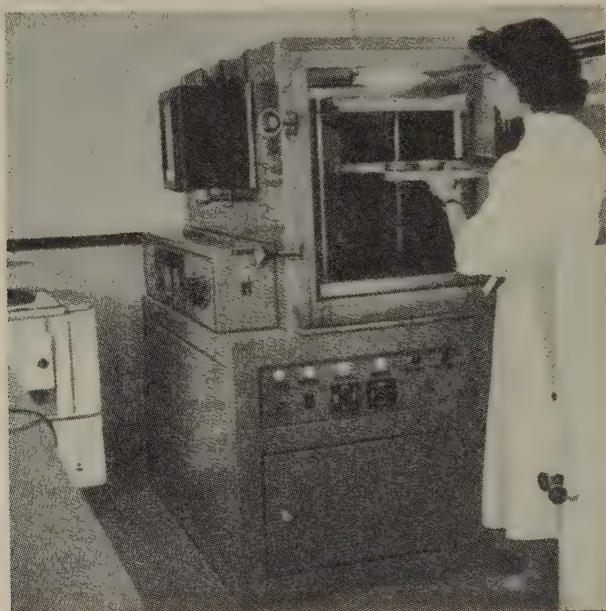


Fig. 7. — Project for making tests into permeability to water vapour.

There is the following equipment in this laboratory :

- bursting strength gauges (éclat-mètres (Lhomme et Argy, Perkins, etc.);
- Puncture Tester;
- dynamometer 250 kg (fig. 6);
- tearing test gauges;
- elasticity test gauge;
- Aminco electric hygrometer;
- Gelbe Tester;
- scales and balances, etc.

- Groote apparatus;
- Biolyon pH-meter, etc.

To complete this equipment another piece or apparatus has just been ordered, the « Weather-o-meter » which can be used to study the artificially speeded up ageing of materials used in the manufacture of packings.

Amongst the activities of the General Laboratory for Packings, tests of permeability to water vapour play a very important part.

For this purpose there is a tank (fig. 7) of 250 dm³ capacity in which it is always possible to obtain a given degree of humidity at various temperatures, the standard method requiring 95 % of relative humidity and 38° C.

The essential characteristics of this tank are on the one hand the very accurate control of the percentage of humidity, to

generator. There are three humidifiers, having powers of 400 W, 400 W and 1 000 W respectively. The rate of humidity can vary in practice between 30 % and 100 %.

The hygrometric degree is controlled and regulated by a psychrometric fitting of two mercury contact thermometers. A recording device is placed on the out-



Fig. 8. — « Müllen » resistance test.

within nearly 2 %, and on the other hand the certainty of having the required temperature to within half a degree.

Heat is obtained by putting into circuit electric resistances without inertia, in sufficient number to obtain the correct regulations at the different temperatures used, which may vary from the atmospheric temperature to 100° C.

These resistances are made of rustless filaments stretched on a frame. The temperature is checked by a mercury contact thermometer.

To obtain the desired humidity, two methods can be used, a humidifier or a

side of the wall; it has two recorders one of which is humidified. This control apparatus inscribes two curves, one blue indicating the dry temperature; and the other red, indicating the temperature of the wet bulb. The hygrometrical degree is given by tables as a function of the difference between the dry and wet temperatures.

* * *

Equipped in this way with a very complete set of equipment, only the more important or newest of which have been described, the General Laboratory for

Packings is available for use by any undertaking, industry or commercial firm which wishes to make tests, studies, trials and researches into their packings as well as into their methods of packing.

In actual fact, the activities of the laboratory are more particularly directed towards wood, cardboard (fig. 8 and 9), plastic materials and to the phenomena

to specialised sections which certain professional organisations have installed in the laboratory the work of which it directs, co-ordinates and supervises.

At the present time, these sections are :

— the « Timber » section, run by the Technical Timber Centre (C. T. B.);

— the « Carton » section run by the Syndicate of Manufacturers of corrugated

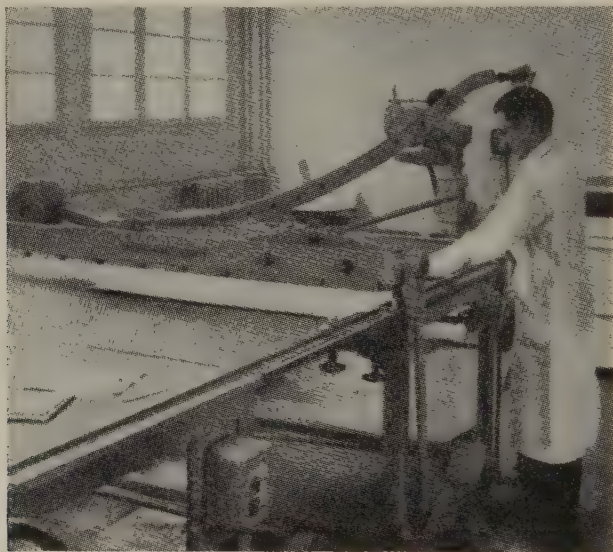


Fig. 9. — View of the « Carton » shop.

of corrosion, transport problems, exterior and interior conditioning operations (fig. 10), the question of handling, etc.

All these activities on the general plane depend upon the authority of the Administrative Council and as regards the carrying out of the work on the management of the laboratory.

The latter makes use of :

— on the one hand, the staff employed by the laboratory, which it recruits and for which it is directly and completely responsible;

— on the other hand, staff belonging

paper, manufacturers of controlled packing cases;

— the « Transport by rail » section, run by the S. N. C. F.

The number of such sections need not be limited to three; the laboratory has amply room for more provided their activities have anything to do with their own special objectives. For example another section « Plastic Materials » is now being studied and will shortly be started.

Finally, on the first floor of the laboratory, there is an Information Centre

intended to deal with the requirements both of the laboratory itself and those of its clients and correspondants, set up by the French Packing and Conditioning Institute, which remains responsible for its management and keeps it constantly up to date about any new facts concerning packing published by the world press.

There is no doubt that such an organisation can be of the greatest service for the

ical value of prototypes of packings designed or approved by the laboratory as far as railway transport is concerned, or to decide about granting the seal of quality to types of packings intended to be used for goods transported by rail;

2) it also makes detailed examinations of packings with which damage occurs too frequently. Collaborating in this case with the S. N. C. F. sub-committee for the



Fig. 10. — « Timber and metal » shop
(making prototypes of packings and wood or metal wedging devices).

scientific obtention of those types and methods of packing most apt to give complete protection, at very low cost, of all goods which have to be moved from one place to another.

In the special field of transport by rail, the special section of the laboratory carries out several distinct activities :

1) first of all it collaborates in the work of general interest which it carries out together with the other sections of the laboratory, either to study the pract-

prevention of damage, it follows up lawsuits due to defective types of methods of packing and suggests the remedies;

3) it also studies on behalf of the S. N. C. F. itself, the most suitable types of packings for the needs of some of its services (signals — electric services — etc.);

4) finally it gives its considered opinion regarding the granting of the seals of quality and approbation laid down in the S. N. C. F. tariff No. 111 and with the departments concerned carries out recep-

tion tests of pallets which can quality for S. N. C. F. tariff No. 114.

To date only the S. N. C. F. has given any practical worth to the seals mentioned above. To the *seal of quality* granted by the laboratory it gives a favourable presumption in case of lawsuit, and will not plead a defect in the quality of the packing to repudiate its responsibility; to the *seal of contract* which cannot be granted without the above, but which is granted much more rarely and only by the S. N. C. F., it grants reduced tariffs applicable to certain goods.

The General Laboratory for Packings is now carrying out the necessary studies to give an official character to its « L. G. E. » seal of quality as well as to get maritime, road and air transport undertakings to give packings bearing this seal certain advantages justified by the efficacy of its protection.

The granting of this seal will of course increase the responsibility of the laboratory, obliging it to control the activities of the manufacturers of the packings

authorised to use this seal so long as they conform to the prototypes submitted, and the quality of the packings which can be examined when in use.

* * *

To conclude, the definition of « good packing » the laying down of its standards and their control are now greatly facilitated by the new organisation of the General Laboratory for Packings, the installations of which are a credit to French ideas and their practical realisations.

On the national plane, it cannot fail to encourage new and rapid progress in the technique of packing, and thereby, in the methods of consigning, transporting, presenting and selling by industry and commerce.

On the international plane, its activities, closely co-ordinated with those of the Brussels, Delft, Rome and London Laboratories for Packings, will bring increased security to the desirable development of exchanges of goods of all kinds.

Widening for « electrification » and repairing the tunnel of Serves

(Paris - Marseilles line),

by M. SABATIER,

Ingénieur Chef de la Subdivision des Ouvrages d'Art de la Région Méditerranée
de la Société Nationale des Chemins de fer français.

(Revue Générale des Chemins de fer, October 1956.)

The Mediterranean Region of the French National Railways has just completed the widening of the Serves Tunnel, situated on the Paris-Marseilles main line between the stations Saint-Vallier and Serves, as part of the works required for the electrification of the Lyons-Avignon section.

The present note gives details of the measures taken which were combined with a general overhaul of the tunnel.

General data.

The Serves tunnel, which is 382 m (1253 ft.) long, was constructed in 1854.

Running near the bank of the river Rhone, from which it is separated by the village of Serves, and skirting National Highway No. 7 (fig. 1), the tunnel had been driven through granite and partially lined with a series of brick vaults of a thickness varying from 50 cm to 1 m.

The maximum rock cover above the vaults is about 30 m (100 ft.). The mountain through which the tunnel is driven is divided into two parts by the « Barres Ravine » where, over a length of about 30 m (100 ft.), the tunnel merely consists of a bare brick vault without mountain cover.

A vertical shaft, dating back to the construction of the tunnel, exists at a distance of 130 m (427 ft.) from the southern tunnel mouth.

The tracks run straight over a distance of 128 m (420 ft.) from the tunnel mouth on the Lyons side and then enter a curve of 850 m (2789 ft.) radius extending through the remainder of the tunnel. A solid invert of varying thickness extends through the whole length of the tunnel. Three drains (one on each side and one in the centre) collect the infiltrating and trickling water.

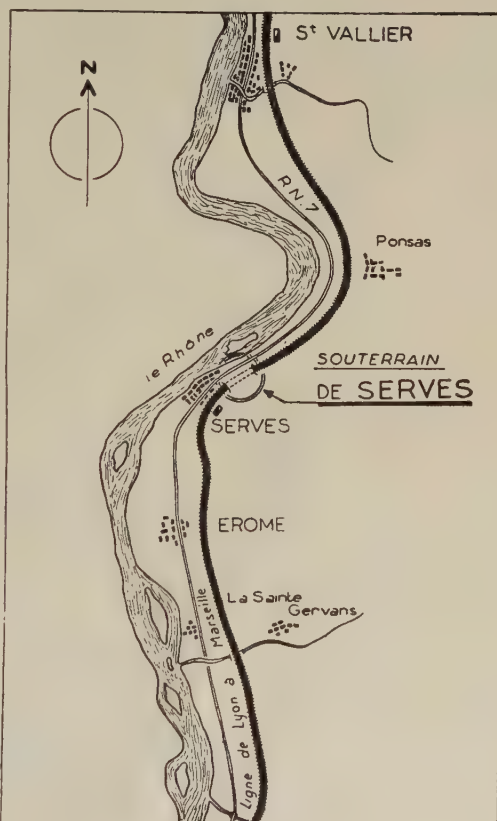


Fig. 1. — Plan of a section of the Lyons-Marseilles line comprising the Serves tunnel (« Souterrain de Serves »).

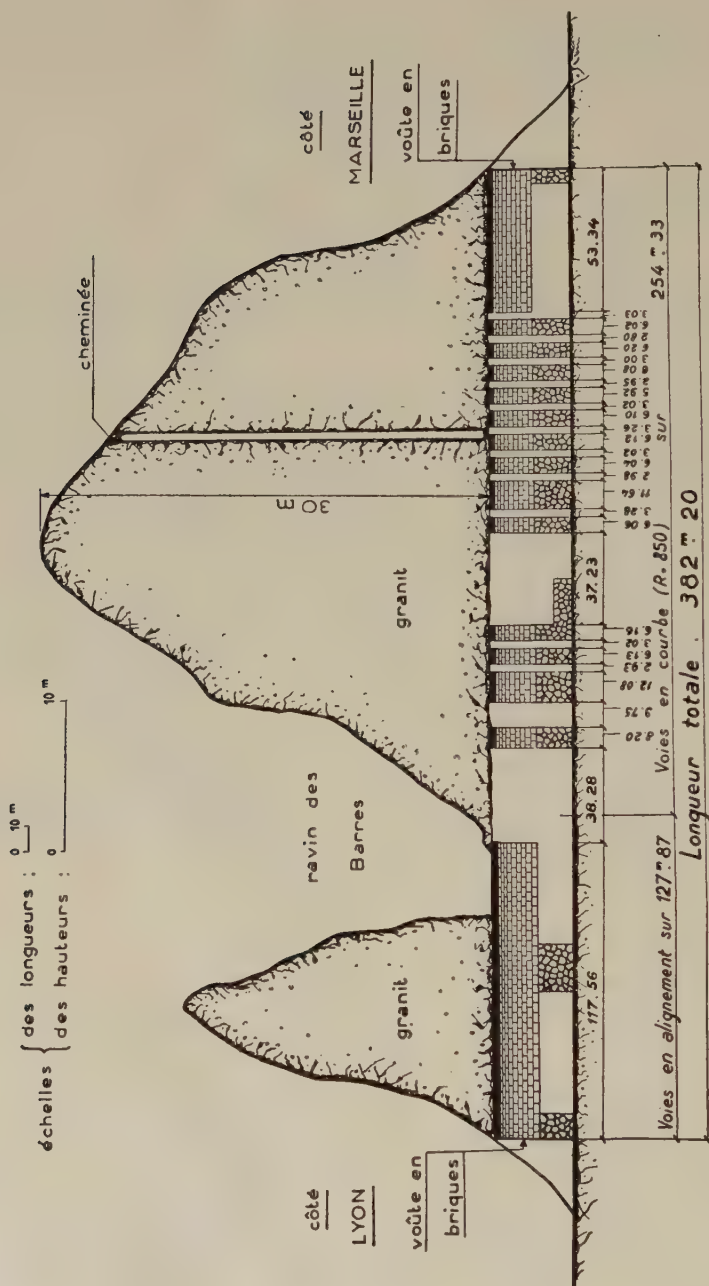


Fig. 2. — Longitudinal section of Servet tunnel.

Côté Lyon = Lyons side. — Côté Marseille = Marseilles side. — Ravin des Barres = Barres ravine. —
 Cheminée = air-shaft. — Voûte en briques = brick vaults. — Voies en alignement = straight tracks. —
 Voies en courbe = curved tracks. — Echelle des longueurs = horizontal scale. — Echelle des hauteurs
 = vertical scale.

The main characteristics of the tunnel are shown in figures 2 and 3.

Solution adopted.

The brick vaults rested either on flanking walls of granite quarry stones, or directly on the rock. Generally, the space between their crown and the rock roof was not filled in (cf. fig. 3). The brick vaults were partly in a poor condition.

Various solutions were examined in order to obtain the tunnel clearance required for electrification.

The solution, chosen for the Horrem tunnel near Cologne, of replacing the tunnel by an open trench was ruled out from the outset. Such a solution, which would have called for the removal of 150 000 cubic metres (nearly 200,000 cubic yards) of granite, would have been very costly.

Nor was it possible to adopt the solu-

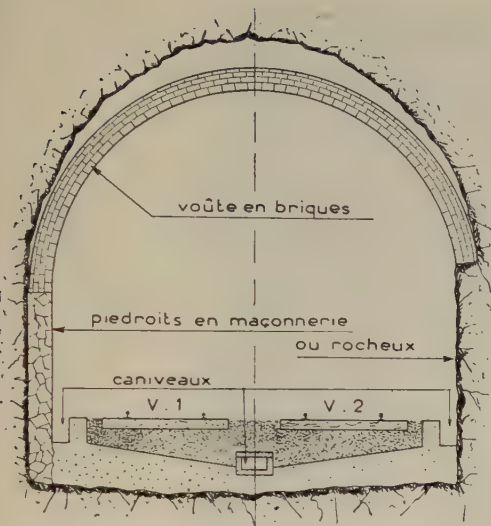


Fig. 3. — Cross-section of Serves Tunnel.
Voûte en briques = brick vault. — Piedroits en maçonnerie ou rocheux = masonry or rock piers.
— Caniveaux = drains.

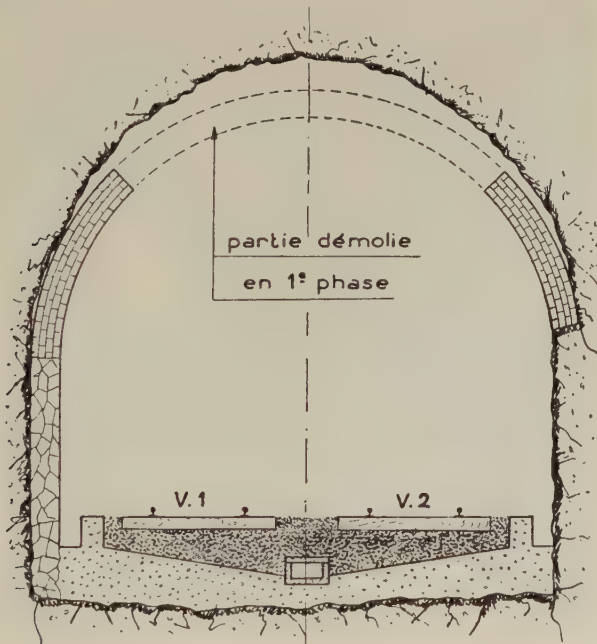


Fig. 4. — Demolition of the brick crown.
Partie démolie en 1^{re} phase = part demolished during the first phase.



Fig. 5. — Demolition of brick vault, south side.



Fig. 6. — Removing the debris of the vault after blasting.

tion of lowering the tracks in the tunnel, because of the disturbance to operation which would have been caused by these important works, and more especially by :

— the demolition of the existing concrete invert;

— the lowering of the formation by about 25 cm (10") in very hard rock (probably necessitating the use of explosives);

— the reconstruction of the three drains.

the free air and locomotive smoke for a hundred years, was the chief argument in favour of this method.

The examination of the results of the Castan survey ⁽¹⁾ showed that, by demolishing the brick arches, the clearance required for electrification would be obtained practically without the need to cut back the rock. In the event, rock removal was confined to a few isolated places.

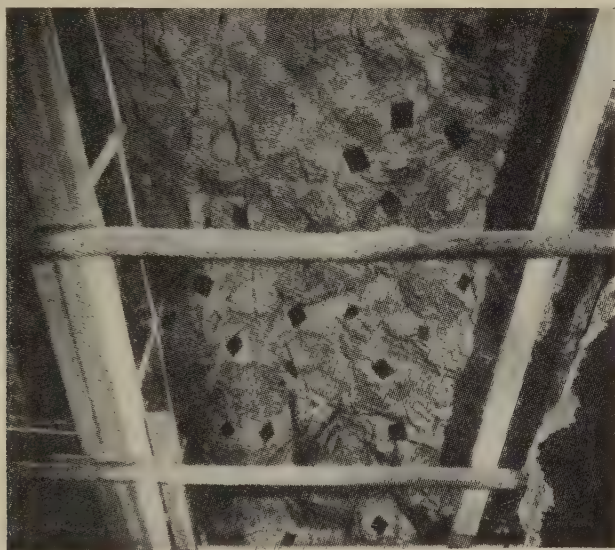


Fig. 7. — Anchor bolts in the rock.

Taking into account the need for repairing and consolidating the brick vaults, this solution was obviously not the most suitable one.

The solution eventually adopted consisted in demolishing the brick vaults so that the rock face was laid bare, and then consolidating the latter by means of « Boltex » and « Ankral » anchor bolts destined to fasten the surface layers to the deeper strata.

The satisfactory showing of the rock in the zones where no facing had been provided, so that the rock was exposed to

⁽¹⁾ See, « Revue Générale des Chemins de fer », January/February, 1952, page 19, a note by M. BOUTELOUP, « Un appareil enregistreur des dimensions des souterrains, dit appareil palpeur-mesureur Castan » (« A device known as Castan feeling and measuring instrument, for the recording of tunnel dimensions »).

See also, « Revue Générale des Chemins de fer », August 1930, page 156, a note by M. VIROT, « Appareil enregistreur de la distance des parois des souterrains par rapport au gabarit de chargement, dit « Appareil Pichon » (« A device known as « Pichon Instrument », recording the distance of tunnel walls in relation to the loading gauge »).

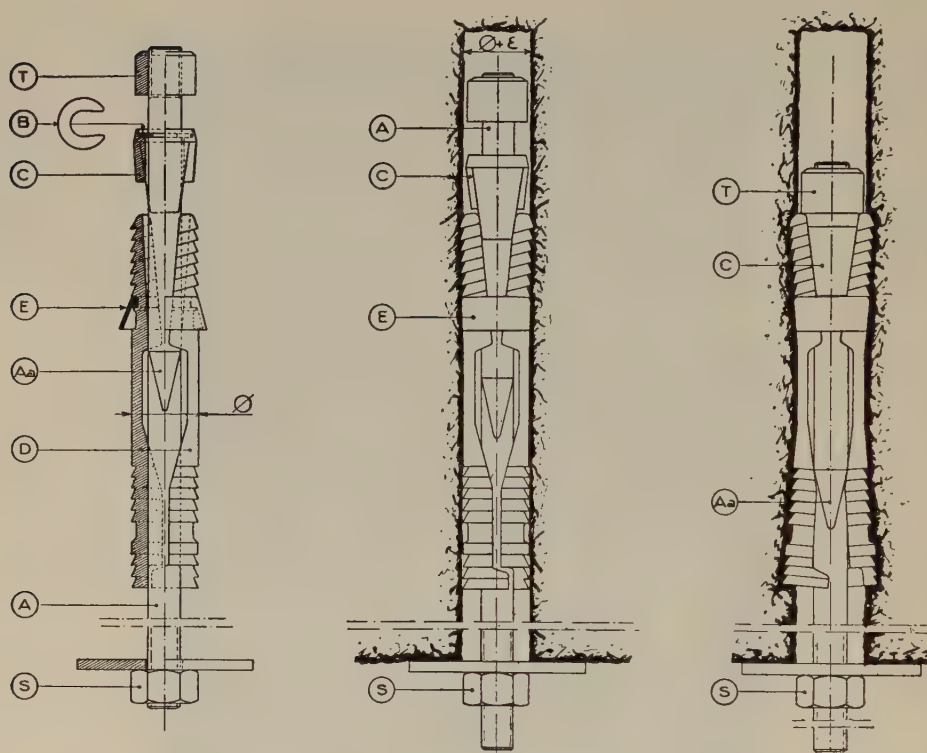


Fig. 8. — Working of « Boltex » anchor bolts.

a) Description of « Boltex » anchor bolt :

Aa = wedge integral with threaded rod A.

C = movable wedge.

D = half-casings.

E = socket of plastics, holding the half-casings.

T = end stop.

B = washer serving as support for the movable wedge.

S = tightening nut.

b) First phase :

(1) Drilling a hole with the diameter $\varnothing + \epsilon$.

The depth of the hole must be at least equal to the overall length of the bolt;

(2) Inserting the « Boltex » bolt (in this position, the threaded end must project from the hole by the height of nut S).

The bolt is kept in position by the friction, against the walls of the hole, of socket E which is locked in the recess provided in the half-casings.

(3) Tightening of nut S. Washer B, moved by rod A, forces the movable wedge C to separate the top part of the half-casings and to ensure a first locking of the bolt.

c) Second phase :

Further tightening of nut S.

Washer B is shorn so that headpiece T comes to rest on wedge C. Wedge Aa separates the bottom part of the half-casings and thus ensures a second locking of the bolt.

Execution of works.

The works were carried out in the time from 3rd October, 1955 to 23rd May, 1956. They can be divided into four main phases during which the speed of trains

passing the tunnel was restricted to 30 km/h (19 m.p.h.).

During the *first phase*, which lasted from 3rd October, 1955, to 9th February, 1956, the crown of the brick vaults was demolished from haunch to haunch, over

a developed length of about 7 m (23 ft.) (fig. 4.) During this period, double-track operation was maintained in the tunnel (fig. 5).

Work commenced at the southern tunnel portal, on the Marseilles side, and was continued without interruption through the whole length of the tunnel.

The vaults were demolished by means of explosives, during intervals between trains. In the zones where the vaults were of great length, sections of 3 to 3.50 m (10 to 11 1/2 ft.) were demolished at a time. Where the vaults were discontinuous, arches of 6 m (20 ft.) length were demolished at a time.

The debris were immediately collected in modern-type tip wagons, placed directly below the zone to be demolished (fig. 6). A platform, protected by faggots, linked the wagons in such a way as to prevent the debris from falling on the track.

Any debris which happened to drop in the space between the tracks was immediately shovelled into the wagons. The latter were moved by means of a « draisine ».

The rock consolidation by means of anchor bolts was carried out as the demolition work proceeded (fig. 7).

Figure 8 illustrates the way in which a « Boltex » anchor bolt works.

Owing to the use of explosives, which permits rapid demolition, it was possible to work in comparatively short intervals between trains (2 h 45 min in the case of vaults of 6 m length).

During the second phase, the demolition was extended to the part of the brick vaults between haunch and springing.

To facilitate this work, the two tracks were interlaced, after one of them was moved 90 cm (2' 11") towards the centre line of the tunnel (fig. 9). This arrangement was continued until the work was completed.

In this way, it was possible to avoid that the tracks were obstructed by debris. The material dropped along the piers

was loaded on wagons and removed during intervals between trains.

This work lasted from 9th February to 10th March, 1956. It was facilitated by the use of « Jumbos », i.e. a kind of steel scaffoldings on small wheels which could be moved as required on rails placed close to the piers (fig. 10).

The demolition of the brick walls proceeded according to plan. The rock laid

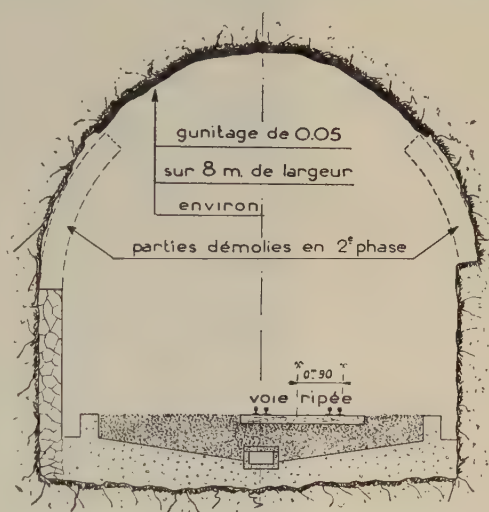


Fig. 9. — Demolition of vault parts between haunch and springings.

Gunitage de 0.05 sur 8 m de largeur environ = gunitage rendering of 5 cm (2") thickness over a width of about 8 metres (26'3"). — Parties démolies en 2e phase = parts demolished during the second phase. — Voie ripée = track moved sideways.

bare by the demolition proved to be sound over the whole length of the tunnel with the exception of a zone of about 25 m (82 ft.) at the northern tunnel portal where the demolition revealed a fractured rock in fairly poor condition.

In this zone, the number of anchor bolts was greatly increased and the rock was lined with a thin vault of reinforced concrete. This work, together with further works required to obtain the necessary clearance for electrification, viz. the



Fig. 10. — General view of a « jumbo ».



Fig. 11. — Construction of vault at the northern tunnel portal.

reconstruction of the vault in the « Barres Ravine », constituted the third phase.

This third phase, which commenced at the same time as the second phase and

ran concurrently with the latter for a time, was completed on 6th May, 1956.

The reinforced concrete vault, made of concrete containing 350 kg of cement per

cubic metre, was constructed in the time from 2nd March to 28th April. It has an average thickness of 60 cm (2 ft.) and is reinforced, on the outside as well as on the inside, by a mesh of steel bars of 12 mm ($\frac{1}{2}$ ") diameter. It was constructed consecutively, progressing from the interior

The reconstruction of the vault across the « Barres Ravine » was carried out in the open. The old vault was used as shuttering after covering it with a layer of sand about 20 cm (8") thick which was destined to protect the new vault against concussions which might be caused by the

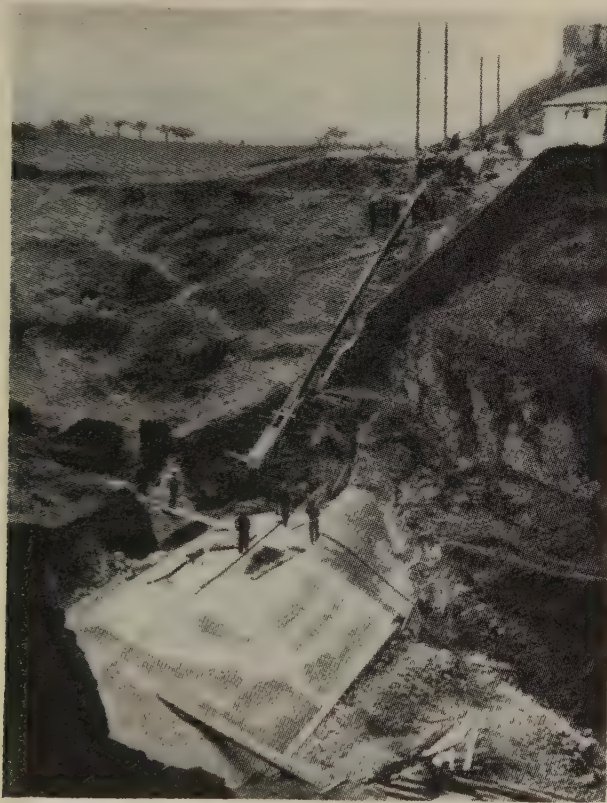


Fig. 12. — Concrete vault at the « Barres Ravine ».

to the portal of the tunnel, in sections of 12.5 m (41 ft.) length, on timber shuttering carried by a centreing of bent rails (fig. 11). The concrete, prepared outside the tunnel, was hurled by means of compressed air on to a working platform supported by a « Jumbo » where it was used immediately.

demolitions of the old vault. A sheet of strong paper was inserted between the sand and the new vault.

This vault which has an average thickness of 60 cm (2 ft.) consists of concrete with 300 kg of cement pr. cubic metre (fig. 12) and rests on solid rock at the springings. The vault was constructed in

sections of 10 m (33 ft.), separated by joints without gap. A caulking of dry mortar was provided at the crown of the vault. Watertightness was ensured by a continuous layer of pumped concrete protected by a 5 cm (2") layer of lean concrete. This was completed after the demolition of the old vault by means of explosives. A drainage system outside the tunnel serves to collect and evacuate the

of the tunnel and over a width varying between 7 and 10 m (23 and 33 ft.), a waterproof coat of cement mortar which, serving as an umbrella, protects the catenary installations. This coat, which has an average thickness of 5 cm (2"), has been applied partly by means of the Sika process (182 m = 597 ft.), and partly by means of the Decolith process (48 m = 157 ft.). In the part where the Sika



Fig. 13. — One of the tunnel portals after reconstruction.

trickling water so that it cannot impair the tighness of that part of the vault which is in the open.

The demolition of the cut stone tunnel portals was carried out by means of hewers' hammers. The new tunnel portals consist of concrete which contains 300 kg of cement pr. cubic metre, and which was not subjected to any surface treatment after the shuttering was removed (fig. 13).

The fourth and last phase lasted from 10th March to 23rd May. It consisted mainly in providing, over the greater part

process was used, the application of the coat was preceded by the construction of a drainage system which ensured the collection and evacuation of water outside the waterproofing.

The work was completed by enlarging the existing refuges along the piers, the construction of new refuges, and the preparation of the anchor devices for the supports of the catenary installation.

Finally, the vertical shaft situated at a distance of 130 m (427 ft.) from the

southern tunnel portal was sealed by a concrete slab reinforced by steel rails. Precautions were taken to drain the water infiltrating through this shaft to the two lateral drains in the tunnel.

The works have been carried out by « Entreprise Borie » who sub-contracted the application of the concrete coating to

« Société Sika » (for the Sika process) and « Société des Grands Travaux Souterrains » (for the Decolith process).

Normal working on both tracks was resumed on 3rd June, 1956 after the ballast in the tunnel had been renewed and the tracks moved back to their original position.

Changing over from the metric to the English standard gauge on the Kindu (Port-Empain) to Albertville Railway (Belgian Congo),

by L. RIPERT,

Ingénieur en Chef de la Société Générale des Chemins de Fer Économiques.

(*L'Industrie des Voies Ferrées et des Transports Automobiles*, July-August 1956.)

Mr. C. CAMUS, Member of the Royal Academy of Belgian Colonial Science put before this body on the 25th November 1955 a paper dealing with the change over in the permanent way gauge and rolling stock on a line in the Belgian Congo. It seemed of interest to publish a detailed summary of this paper which reports the methods of organising the work and the technical processes used which made it possible to complete the work in a very short period.

REASONS FOR THE CHANGE.

The Belgian Congo Railways were built to different gauges, mainly 1 m and 1.067 m (fig. 1). The metre gauge was adopted for the C.F.L. system built in 1902, as was the general practice in countries where the metric system is used ⁽¹⁾. The B.C.K. Railway was built in 1906 to the standard British gauge (3' 6", i.e. 1.067 m) as it connected up with the adjoining lines having this gauge (Rhodesian and Mozambique railways) ⁽²⁾.

These two railways were not connected. Their linking up (between Kamina and Kabalo) involving a distance of 465 km was undertaken in 1953 and should be completed by 1956. This will make it possible to link up the lines serving the provinces of Katanga and Kasai, about 2 500 km, with the 839 km of the C.F.L. completed by river and lake navigation services and to join up the South Africa system to that of Angola through the B.C.K. and C.F.L., making a total of about 20 000 km of line.

The Committee for the Standardisation of the Belgian Congo ⁽³⁾ Railways decided that this line linking up the B.C.K. and C.F.L. should be laid to 1.067 m gauge. In order to avoid the nuisance of transshipments of freight, its opening to traffic meant widening the metre gauge line of the C.F.L. between *Kindu (Port-Empain)* and *Albertville* to 1.067 m. This change is the subject of the present note.

⁽¹⁾ The Upper Congo to the Great African Lakes (C.F.L.) Railways consist of two separate sections, with a total length of 839 km:

— Stanleyville to Ponthierville: 125 km;
— Kindu (Port-Empain) to Albertville via Kongolo and Kabalo: 714 km.

⁽²⁾ The Lower Congo to Katanga Railway Company (B.C.K.) operates about 2 500 km of lines:

— from Port-Francqui to Sakania (Rhodesian frontier);
— and from Tenke to Dilolo (Angola frontier).

⁽³⁾ The work included three million cubic metres of embankments and four bridges, one of them 750 m long.

WORK INVOLVED.

The « Operation Grand Ecart » as it was known to the staff, included the change over :

in the case of the permanent way of :
800 km approx. of track, 714 km being
main line;

350 switches;

First stage. — Preliminary arrangements in connection with orders for permanent way and rolling stock materials passed thirty years ago;

Second stage. — Study of the ways of adapting the old stock, starting from 1949, and carrying out the preparatory work between 1954-1955;

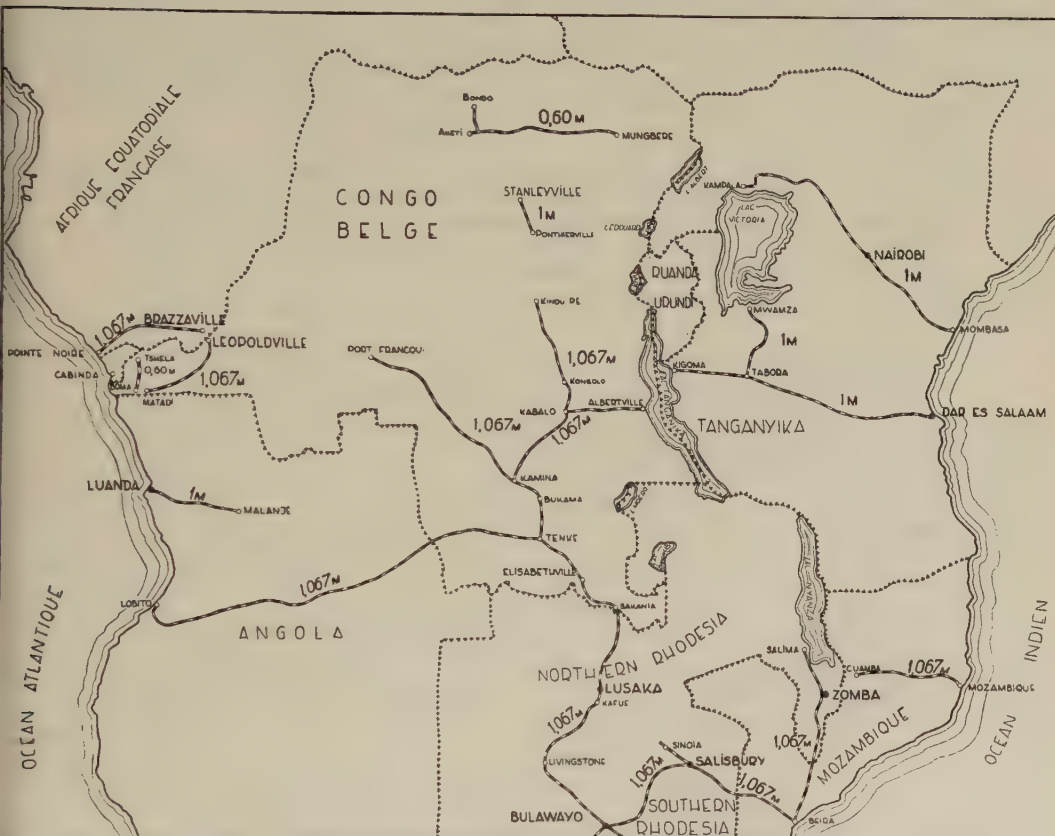


Fig. 1. — Map showing the gauge of the railways in the centre of Africa.

in the case of the rolling stock :

38 locomotives;

about 500 wagons and coaches, mostly bogie stock, cranes and trolleys.

The work was carried out in three main stages :

Third stage. — Work of switching over to the new gauge from the 1st to the 10th September 1955.

The report which follows deals first of all with the modifications made to the permanent way, and then those affecting the rolling stock.

I. MODIFICATIONS TO THE PERMANENT WAY.

A. Preliminary arrangements.

As soon as the operation was decided upon, it was taken into account when ordering new materials.

New sleepers with « six holes ». — The track includes two types of rails :

— that used in its construction : 24.4 kg per metre ($I/V = 90 \text{ cm}^3$);

— the new type : 29.3 kg ($I/V = 110 \text{ cm}^3$).

It was decided that in order to allow for the change over from one gauge to the other in the future, the simplest solution was to :

— leave one line of rails in position and move the other line 67 mm outwards;

— not to make use of any such arrangements as saddles which would make it possible to avoid increasing the number of holes to be drilled, but to adopt a so-called « six hole » sleeper having :

— four standard holes of 46 mm $\times$ 22 mm;

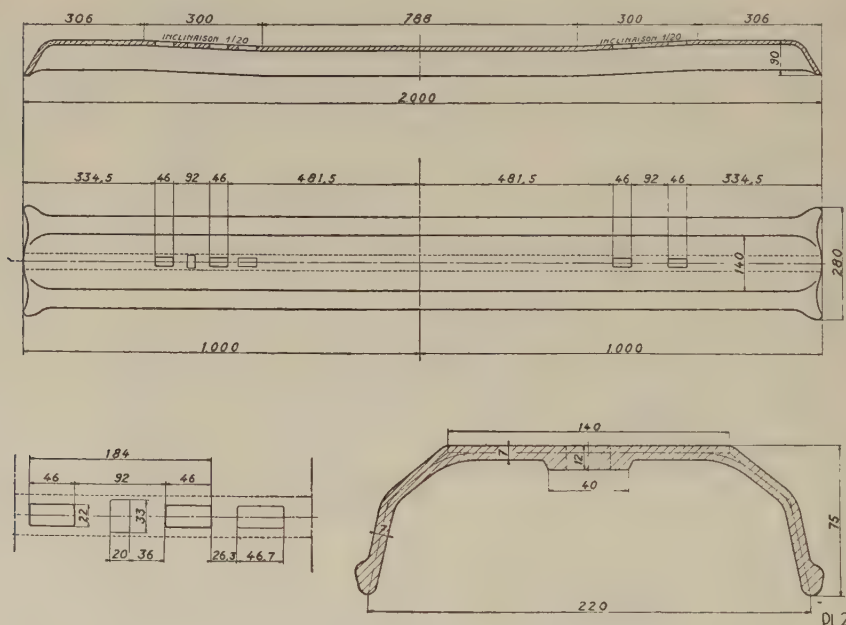


Fig. 2. — « Six holed » metal sleepers.

The sleepers, which are mainly metal ones, numbering some 950 000 are also of two types. In addition, there are some 120 000 wooden sleepers.

The new metal sleepers for the 29.3 kg rails had to be usable with the 24.4 kg rails to strengthen the track and with the English gauge as well as the metric gauge.

— two additional holes, one sited transversely between two standard holes of reduced size (33 $\times$ 20 mm), and the other longitudinally (fig. 2);

— to design two new types of clips, one of which would be reversible and have two bearing faces usable with 24.4 kg or 29.3 kg rails.

These arrangements made it possible to lay the track :

— to the metric gauge (before the change-over) with an excess gauge of 13 mm for both types of rails;

— to the English gauge with an excess gauge of 14 mm in the case of the 24.4 kg rails and with three spacings in the case of the 29.3 kg rails (without excess gauge and with the two excess gauges of 9 mm and 18 mm on curves).

About 150 000 new sleepers of this type were laid.

Adaptation of the old metal sleepers.

It was necessary that the alteration of the 800 000 metal sleepers used on the greater part of the line should be carried out without seriously affecting the running of the trains, and preferably leaving them in place to avoid disturbing their seating in the ballast. In addition, the method had to be as cheap as possible on account of the great number of sleepers to be dealt with.

Conclusions similar to those arrived at

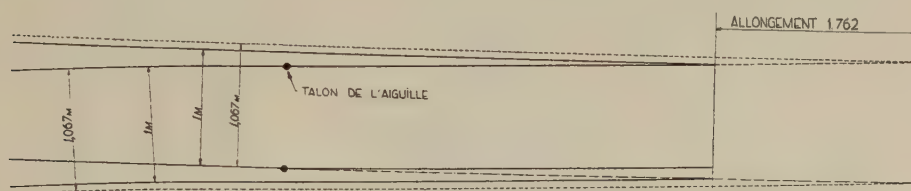


Fig. 3. — Layout showing the extension of the switches.

Talon de l'aiguille = heel of the switch. — Allongement 1.762 = extension.

New switches.

Only 29.3 kg type rails are used on the new switches. In view of the fact that they would be altered to the 1.067 m gauge, the following operations had to be allowed for :

— drilling supplementary holes in the sleepers for moving over the two outer lines of rails by 67 mm;

— moving the switches longitudinally by 1.762 m and giving them an excess gauge;

— inserting sections of rail 1.762 m, and three additional sleepers in order to extend the equipment when increasing the gauge (fig. 3).

B. Studying and carrying out the adaptation of the old material.

When it was decided to alter the gauge, a study was made of methods of adapting the old material and this was then carried out.

in studying the six holed sleeper led to a decision that only one line of rails would be moved so that a group of two additional holes had to be drilled. It was moreover possible to drill these old type sleepers with exactly the same sort of holes so that the fastenings could be re-used (fig. 4).

Amongst the drilling methods studied, the two following were adopted :

— cutting out with an acetylene blow-pipe;

— punching.

a) With the first method, automatic guiding of the blowpipe was necessary to get sufficient accuracy. After study and trial, the following equipment was adopted :

— a moveable part carrying the blow-pipe and gauge for the holes;

— and a « magnetic finger-guide » forming part of the table fastened to the sleeper, which moves the blowpipe in accordance with the gauge.

Cutting with a blowpipe has the advantage that the sleepers remain undisturbed, but it also has various drawbacks: the holes obtained in this way are not perfect, certain sleepers were « refractory » in 3 to 5 % of the cases and there was a risk of a change in the metal.

b) Punching was easy, accurate and economical, but it meant taking up and

year, nearly 570 000 sleepers were prepared by these methods, 49 % approximately being drilled by blowpipe and 58 % by the punching machines. The output of the blowpipe equipment was 100 holes per man-day.

Adaptation of wooden sleepers.

To adapt the 112 000 wooden sleepers laid on certain sections, two additional holes had to be drilled. This operation

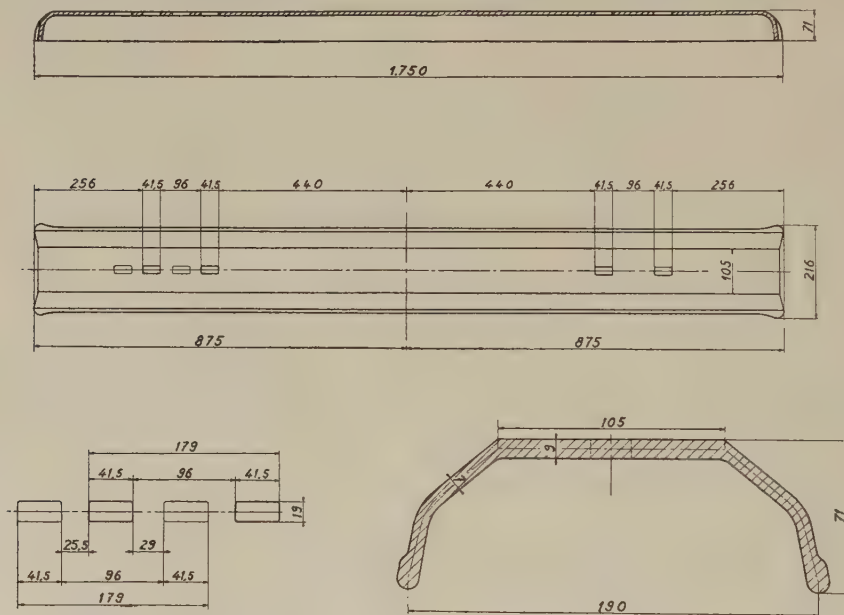


Fig. 4. — Adaptation of the old metal sleepers.

relaying the sleepers. Tests shows that according to the nature of the ground and the season of the year, the sleeper bed remained intact or else broke up, and in the latter case it was necessary to pack it again.

It was decided that one method was as good as the other, and the cost about the same. It was decided to use both methods, and in addition to the punching machines in the shops, twenty blowpipe equipments were used and four specially designed sleeper punching machines. In one

was carried out as late in the programme as possible to avoid the new holes getting damaged or blocked up. The holes which were no longer required were afterwards plugged.

Adaptation of the turnouts.

The old turnouts — about 120 — were laid on wooden sleepers. These were replaced by special metal sleepers, made up from ordinary sleepers of the old type taken from the open road, cut up, welded end to end and drilled as required.

C. The actual changing of the gauge.

Preliminary studies. — Before commencing to change over the gauge, everything was decided upon in detail, the work-

— determination of the time to be allowed for the various operations and labour requirements;

— allocation of the work and working programme for each man;

*PENDULE
de SABOT*

*FIXATION des SABOTS de FREIN
sur leur TRINGLE d'ECARTEMENT*

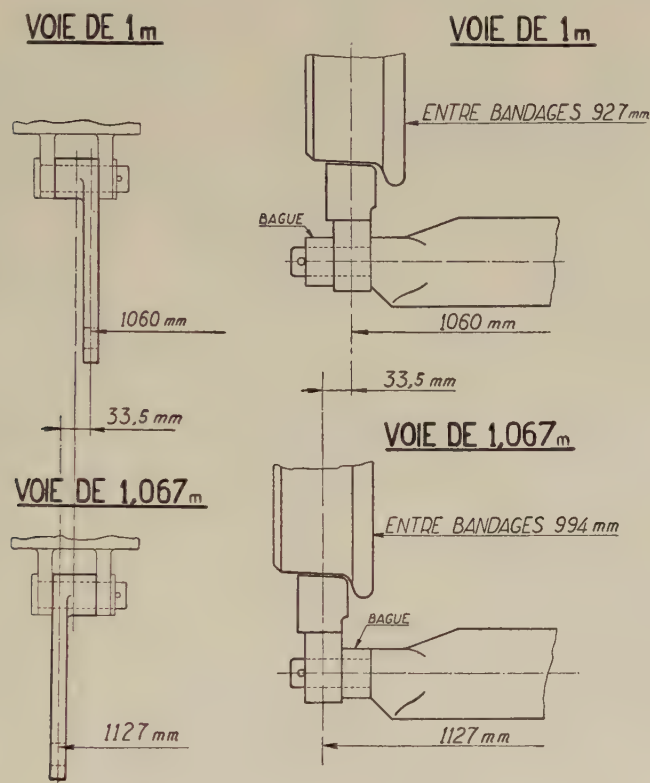


Fig. 5. — Modification of the gauge of coaches and wagons.

Pendule de sabot = brake shoe pendulum. — Fixation des sabots de frein sur leur tringle d'écartement = fixing the brake shoes on their gauge rods. — Voie de 1 m = 1 m gauge line. — Entre bandages = between tyres. — Voie de 1.067 m = 1.067 m gauge line.

ing plan covering in particular the following points :

— study of the various operations and the methods of carrying out each one;
— designing specially adapted tools;

— clearing the maximum amount of freight traffic before starting on the work;

— transport of the additional labour to the site, and keeping them supplied with materials and tools;

— sending the rolling stock to the shops where the alterations were to be carried out;

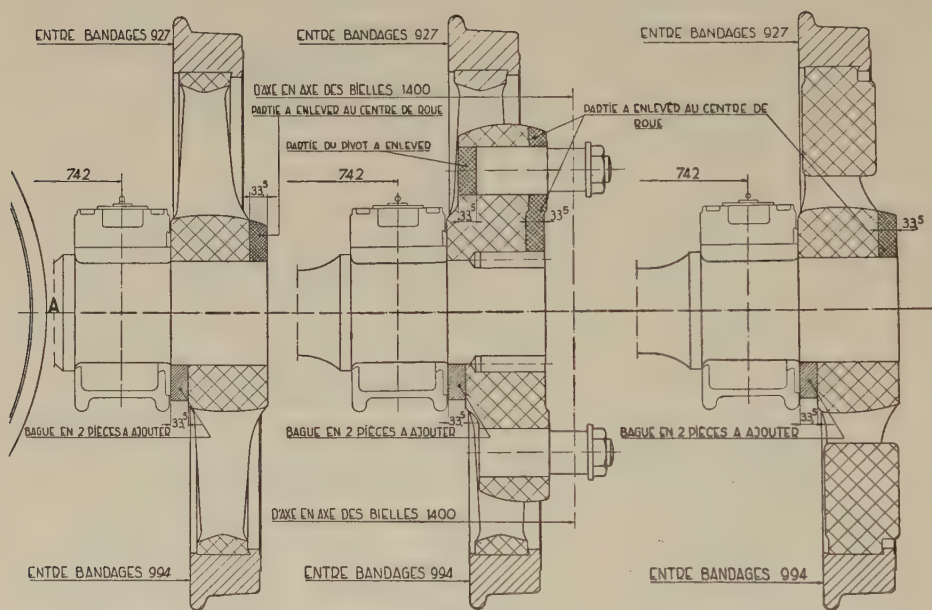
— establishing telephone communication between the various gangs;

— organising the movements of the supervisory staff, the materials, the accommodation and medical care of the staff.

in the radius of the line of rails to be moved;

— in the neighbourhood of certain fixed installations, especially in the case of certain bridges, arrangements to take into account the 3.5 cm out of centre of the increased gauge line in comparison with the metric gauge.

VOIE DE 1^m



VOIE DE 1.067^m

Fig. 6. — Modification of the gauge of locomotives by moving the wheel centres outwards.

Explanation of the French terms :

Entre bandages = between tyres. — D'axe en axe des bielles = from centre to centre of the rods. — Partie à enlever au centre de roue = part to be removed in the centre of the wheel. — Partie du pivot à enlever = part of pivot to be removed. — Bague en 2 pièces à ajouter = ring in two parts to be added.

Amongst the detailed operations thus perfected, mention may be made of :

— in the case of certain curves, the preparation of shorter or longer sections of rail than those existing, in order to take into account the reduction or increase

Carrying out the work.

On the day « J — 1 » the fastenings were removed from every other sleeper, and the last trains were run to bring up the rolling stock and additional labour force (fifty Europeans and one thousand native workers).

On « J » day, the 1st September 1955, all traffic came to a standstill. Each gang, consisting of twenty to thirty natives, equipped with mechanical coachscrew drivers, was responsible for converting to the new gauge a section of approximately 10 km. Gangs of fifteen men dealt with the track installations and sidings.

II. MODIFICATIONS TO THE ROLLING STOCK.

Main operations allowed for.

In the case of coaches, wagons and tenders, the modifications provided for some considerable time ago included the following operations :

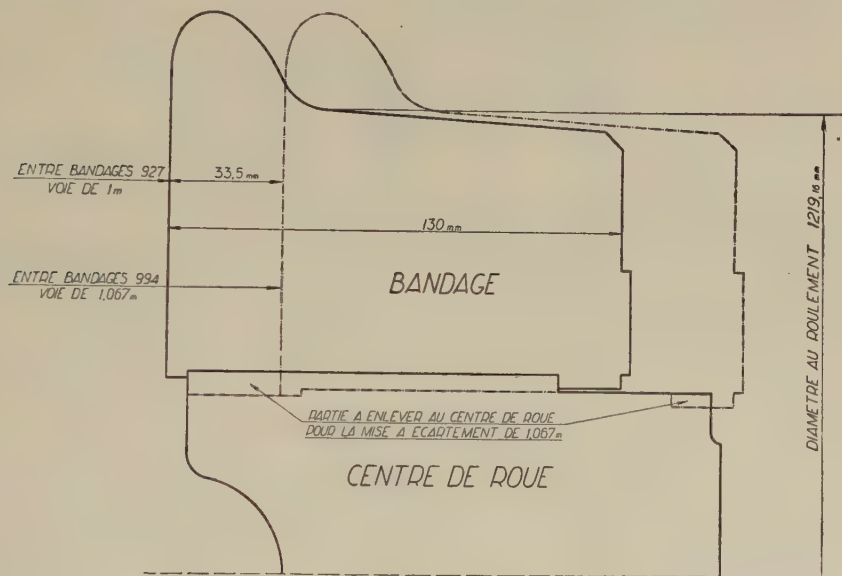


Fig. 7. — Modification of the gauge of locomotives by moving the tyres outwards.

Bandage = tyre. — Centre de roue = wheel centre. — Entre bandages 927. Voie de 1 m = between tyres 927 - metre gauge. — Partie à enlever au centre de roue pour la mise à écartement de 1.067 m = part to be removed from wheel centre to make it 1.067 m gauge. — Diamètre au roulement = turning diameter.

The total labour force allocated to the work was two thousand native workers under the control of forty-six Europeans.

On the seventh day, five days in advance of the programme, the first check trains were run on the line laid to the new gauge.

On the eleventh day, normal traffic was resumed; it was therefore only interrupted for ten days.

— driving out the wheel centres on the axles by a press by $\frac{67}{2} = 33.5$ mm outwards;

— moving the brake shoes on their gauge rods 33.5 mm outwards and turning over their pendulums the stem of which is out of centre to the articulation socket (fig. 5).

In the case of locomotives, the mechanism was set to correspond with the gauge of 1.067 m when they were built. The brake shoes were also moved as in the case of the wagons and coaches.

The sets of wheels were modified, first by driving out by a press the wheel

one at *Albertville*, the other at *Kongolo* in the middle of the line. The main arrangements at each of these workshops were as follows :

— group of seven to eight sidings for parking the vehicles, to metre gauge as well as the lines giving access to them at

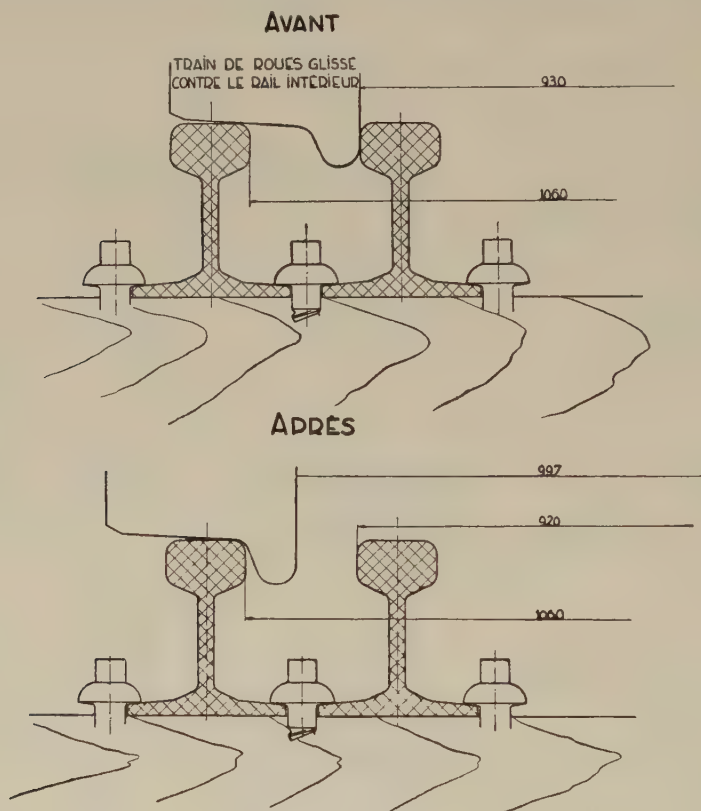


Fig. 8. — Sections of the alteration sidings.

Avant = before. — Train de roue glisse contre le rail intérieur = wheel sets slide up against the inside rail. — Après = after.

centres (fig. 6) and then, more simply, by replacing and driving out the tyres (fig. 7).

Setting up of workshops.

To cope with the alterations to coaches and wagons, two workshops were made,

the end A, the lines at the end B and the corresponding cross line being laid to 1.067 m gauge;

— working place for carrying out the alterations consisting of three tracks to metre gauge at the entry turning into the English gauge after 7 m, check-rails being

fitted on the inside to assure the guiding of the tyres by the inner faces in order to prevent derailment of the bogies before they had been altered (fig. 8);

— three sites on these tracks where wagons could be hoisted and three 500 t presses designed to enable the wheels of bogie trains to be driven outwards without removing them;

— electric lighting and power;

— spare axles, sets of wheels and bogies to meet with unforeseen circumstances.

The work was carried out as follows : two 1 m gauge locomotives took the wagons from the parking sidings at the end A and pushed them to one of the alteration lines; one of the two 1.067 m gauge locomotives waiting on the cross line before the work started, then removed wagons after they had been altered, over the cross line onto the parking sidings at end B. These sidings were changed over to 1.067 m gauge as the 1 m gauge wagons were removed.

Carrying out the work.

On « J » day, the wagons were dealt in the workshops in the following order :

— as soon as a wagon arrived at the alteration siding, the brake rigging was disconnected:

— the wagon was then jacked up to enable the bogies to be cleared;

— the position of the brake shoes was altered;

— the bogies were hoisted by a Hyster crane which moved them over to the press;

— the wheels were driven outwards;

— the bogies were then collected and moved by the crane;

— the bogies were put back in place;

— the brake rigging was connected up.

In the case of locomotives, most of the large engines with 6 or 7 axles, the tyres were replaced in the shops and the diameter of the wheel centres reduced.

Sixty-four Europeans and one thousand native workers carried out these alterations, working day and night.

The total labour force dealing with the « Operation Grand Ecart » was one hundred and ten Europeans and three thousand natives.

The cost of the operation was fifty million Belgian francs.

CONCLUSION.

The success of this operation, which was carried out so rapidly that apart from local users, the trade hardly noticed the interruption to the traffic thanks to the arrangements made, can be attributed to the following chief reasons :

— from the technical point of view, to the very thorough preparations made, the complete planning covering all details of the work, as explained above, which made it possible to get a better output than that expected, in spite of the lack of experience of the additional staff;

— from the human point of view, to the enthusiasm of all the workers, both temporary and permanent staff, in spite of the difficult working conditions and uncomfortable lodgings.

This enthusiasm was manifested in particular by the part played by retired workers who had laid the first line fifty years ago, whose children and grandchildren are now railway employees.

The author of the report insists upon the complete collaboration manifested in this case between European and native labour.

System of resilient rail mounting.

New principle combines positive location of rails with elasticity,

by O. H. VARGA, M.Sc., A.M.I.Mech.E., and L. A. JEBSON.

(*The Railway Gazette*, November, 2 1956).

For some years, development work on resilient-grip fastening methods has been carried out by Seetru Limited in conjunction with L. H. Newton & Co. Ltd., Birmingham, the British licensees. The methods applied use elements of substantially resilient polymers, such as natural and synthetic rubbers, and, to some extent, plasticised polyvinylchloride, as the actual securing medium. One of the resulting products is the Seetru resilient-grip mounting bolt. The special application of this work to railway tracks has evolved a new system of resilient rail mounting for all types of sleepers, and for concrete sleepers in particular.

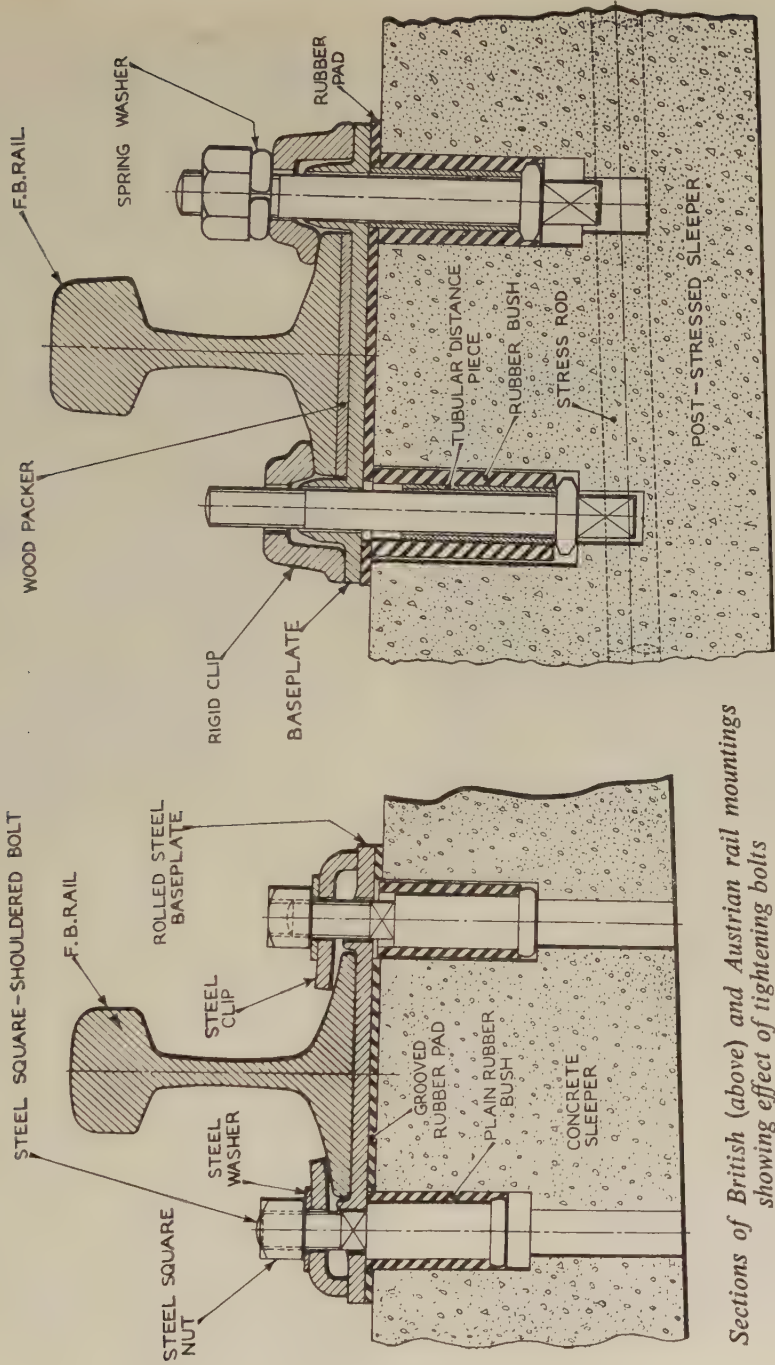
The basic problem of rail mounting consists in providing adequate location for the rail — the more positive, the better — both against longitudinal slipping and lateral displacement, and at the same time imparting to it an essential measure of resilience. This clearly involves a difficulty where the actual means of holding the rail itself are, at the same time, the elastic constructional elements, for if they are inadequately tensioned, their locating and holding power on the rail will be insufficient, and, if they are too heavily pre-loaded, the effect of their elasticity on the mounting, as a whole, may be lost. Thus, anything like the desired result can only be achieved by a more or less critical compromise. This difficulty is completely eliminated in the new system.

The rail foot is carried on a compact and rigid baseplate, which, in turn, rests on a rubber pad of equal size placed direct on the surface of the sleeper. The rail is secured to the baseplate by means of two simple, strong clips and two bolts, each with a nut on top and a shoulder abutting direct against the underside of the base-

plate. The clips need not be particularly flexible, and therefore need not be made of an expensive spring steel. The metal components are robust and the nuts can be tightened quite firmly, without regard to any pre-determined limit. The rail is tied to the baseplate with great strength, through direct metal-to-metal contact, and this can be made more than adequate to hold the rail against any longitudinal slipping, even under arduous conditions of heavy train braking. Laterally, the rail is firmly located between the ribs of the baseplate, and rail, baseplate, clips, and bolts together form essentially one single, rigid, assembled structure.

The round bolt shanks, below the baseplate, pass through the rubber pad, and enter preformed holes in the concrete sleeper, in which they are surrounded by tough rubber sleeves. When the bolts are pulled up, the rubber sleeves are compressed axially. This causes them to expand radially and engage the walls of the sleeper holes with a firm, resilient grip.

When compressed, the rubber squeezes around the bolt head, which is smaller than the bore of the hole, and ensures that there is substantially complete mechanical and electrical insulation between the bolt and the concrete. The amount of axial compression of the rubber sleeve is controlled by the excess of the free length of the rubber sleeve over the bolt length between head and abutment shoulder. This is so dimensioned that in the tightened up condition the resilient grip of the rubber ensures a firm connection between the rail mounting assembly and the sleeper and permits the rail mounting to perform small vertical oscillations relative to the sleeper without



Sections of British (above) and Austrian rail mountings showing effect of tightening bolts

slippage between the skin of the rubber and the concrete. At the same time, the compression of the rubber sleeve is limited, so as to prevent excessive bursting loads being developed in the rail foundation.

Assembly.

The mounting is assembled by dropping the bolts, with the rubber sleeves on them, head first into the sleeper holes. The rubber sleeves, in their free state, enter the concrete holes easily. To prevent the bolts from falling through the sleeper, the holes are either moulded blind, or with a reduced bore at the lower end. The rubber pad and then the baseplate are slipped over the projecting bolt shanks, and the mounting is then ready to receive the rail. When this has been placed in position, the clips are fitted, and the nuts are applied to the bolt threads.

When the nuts are tightened, the bolts are pulled up until the bolt shoulders abut against the underside of the baseplate. During this stroke the rubber sleeves are compressed axially by the required, predetermined amount. Once the bolt shoulders are in contact with the baseplate, no further compression of the rubber sleeves is possible, but the final tightening of the nuts serves to tie the rail firmly to the baseplate-and-bolts assembly, by a metal-to-metal grip throughout, and independently of the grip of the rubber in the concrete.

To prevent any rotation of the bolt on initial screwing of the nut, the bolts may be formed with a square shank portion to pass through corresponding square punched holes in the baseplate. The rail mounting can also be dismantled quickly, and, in general, the bolts and rubber sleeves may be withdrawn without difficulty when the nuts and so on have been removed. If, after years of service, the rubber grip does not completely relax, the bolts and rubbers may be driven out from the bottom of the sleeper through the holes. The sleeper itself is not damaged by the removal of the rail fixing components, and if desired, a new set of rubber components can be fitted.

Absence of critical tensioning.

Although the fastening of the rail to the baseplate assembly and of the mounting, as a whole, to the sleeper is achieved by the same set of bolts, the two functions are quite separate and distinct. Thus the rail is secured to the mounting with absolute firmness, but this does not in any way affect the resilience of the system, which depends upon the fact that the assembly, as a whole, is floated in rubber on the sleeper. Thus there is no critical tensioning of the assembly: the nuts may be pulled up firmly with long spanners, and the required degree of elasticity is safeguarded by the design of the mounting components.

The longitudinal location of the rail is secured in the first instance by the grip of the clips. The lateral location, and indirectly also the longitudinal location, of the whole assembly is by the bolts. As rubber is volumetrically practically incompressible, the possibility of any radial displacement of the bolts in the sleeper holes is small, and accordingly, the accuracy of the track gauge is fully safeguarded.

Insulating properties.

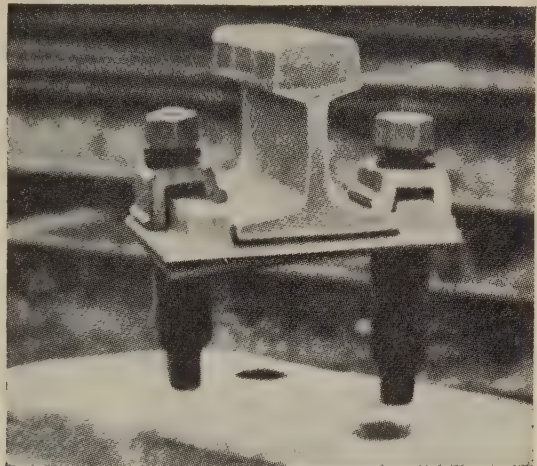
The rubber pad and the rubber sleeves between them ensure that there is no direct contact between the metal parts and the sleeper, and, provided water does not stand in the sleeper holes up to the bolt heads, this achieves the required degree of electric insulation between the rails. Mechanically, the resilient rubber mounting offers important advantages. The metal-to-metal grip between clip, rail, and baseplate is protected from shaking loose by the elastic support provided by the rubber for the entire unit. The rail and rail mounting can oscillate vertically, relative to the sleeper, without disturbing the fastening. An undulating movement of the track is always apparent, particularly in front of an on-coming train, and the fact that the rail can lift slightly, without pulling the sleeper up and subsequently ramming it down again, reduces wear on the sleepers and disturbance of the ballast.

This important freedom of undulation of the rail can be considerably greater and more effective with the present system than with other spring fastenings because the holding and location of the rail is independent of the elastic suspension. Where only spring clips and so on hold the rail their pressure has to be such that the possibility of vertical rail movement is severely limited.

Because of the resilient connection between track and sleeper, the holding power

tinuous rail foundations and in wooden sleepers. The rubber grip in drilled holes in the sleeper does not damage or fray the wood and is very powerful and reliable, but the bolts can also be withdrawn and re-inserted without difficulty.

The compressed rubber sleeves set up radial bursting stresses which have to be resisted by the foundation. The radial stresses can be kept to a low value, and most foundations and sleepers can readily withstand these. The pre-tensioned multi-



Seetru test mountings showing British type, with standard British Railways clips, on the left, and the Austrian experimental type on the right.

which has to be developed by the mounting in the sleeper is much less than would be required by a rigid fixing, and, consequently, the bursting forces set up by the rubber in the sleeper can readily be kept within suitable limits. The separation of the metal parts of the mounting from the sleeper or foundation promises a substantial reduction of rail noise.

The principle of the Seetru resilient rail mounting system is carried out with essentially simple components, and no complicated, critical, or elaborate manufacturing process is involved in the production of any of them.

The system can readily be used on con-

wire type of concrete sleeper is particularly well suited to resist internal loads at right angles to the sleeper axis, but some difficulty is experienced with the single-rod type post-tensioned sleeper. In this design, the stressing rod passes through a hole longitudinally through the centre, and the bolt holes have to be moulded on either side of it. Thus, there is no reinforcement between the holes and the side of the sleeper. Instances have been experienced of a sleeper segment braking away on pulling up the bolts, particularly with high rubber compressions, and with the line of fracture passing through the moulded holes.

For this reason, in the application of

post-tensioned concrete sleepers, two rods must be used, one placed on either side of the centre line. The bolt holes are then moulded on the central axis of the sleeper, and the reinforcing rods on either side greatly add to the resistance of the concrete against radial spreading forces in the holes.

The actual grip of the rubber in the sleeper hole can be made of almost any desired magnitude. The important factors are the coefficient of friction between the rubber and the concrete, the length to radial thickness ratio of the rubber sleeve, and the extent of the radial clearance between the wall of the hole and the round bolt head, through which the rubber can squeeze when it is axially compressed. The grip which can be developed in the concrete sleeper is fully equivalent to the grip of concrete spring spikes in wooden sleepers.

Rubber pads.

The rubber pad used is preferably of a low-set natural rubber compound, containing a relatively high proportion of pure gum mixed with coarse grades of carbon black. This follows the general development of rubber pads for track use, and the hardness of suitable pads lies between 45 and 65 deg. Shore Hardness. Latest practice in this country also favours a fairly substantial rubber pad, about 1/4 in. thick, and most pads in this country and abroad are also fluted in various ways to provide flexibility in the central portions, where otherwise the rubber would be substantially confined.

The rubber sleeves are preferably harder than the pad, of about 70 to 75 deg. Shore Hardness, and they may be compounded of natural or high-grade synthetic rubber. The compounding is designed for good resilience and for good ageing properties, but abrasion resistance is also important, and this calls for the use of some finer carbon black grades. Rubber pads give very efficient and reliable service for years, and the rubber sleeves are used under

particularly favourable conditions, in darkness with virtual exclusion of air, oil, and so on, and mainly in a static form of loading. Experience has shown that the rubber grip remains efficient and reliable for years, and does not suffer any sudden deterioration even after long service, when the rubber sleeve may show signs of hardening.

Experimental British track.

A test track laid in this country differs in some details because the test installation was made as economical as possible, and used existing track material as far as practicable. The bolts are formed without a shoulder, and, instead, a loose steel distance tube is provided inside the rubber sleeve, surrounding the bolt shank, and resting on the shank side of the bolt head. This steel tube is shorter than the free length of the rubber sleeve by a carefully predetermined amount. When, on pulling up the bolt, the axial compression of the rubber sleeve has taken up this difference, the steel distance tube butts against the underside of the baseplate, and then serves the same purpose as the shoulder on the bolt shank in the foregoing description. The two methods are thus equivalent in mechanical performance. Both plain and grooved rubber pads were used in the test track. The spring clips, of a type in current use by British Railways on points and crossings, are not necessary for the system. Their use makes the test lay-out considerably less compact than the production design.

A slot in the top of the bolt shank is intended to enable the bolt to be held against rotation on initial tightening, or on releasing. This screwdriver slot has not proved particularly useful, however, because the bolt was sitting too low in the sleeper to enable the slot to be held effectively while the nut was first applied. Also, the slot is considered to be insufficient to hold the bolt on release if the nut should have rusted on. If an anti-rotation device is required, the square hole in the baseplate in conjunction with the square shank is the best solution.

Experimental Austrian track.

An experimental Seetru track was laid down in Austria on a slightly sloping stretch of the main line to the west of Vienna, where the rail mountings are subjected to the full braking effect of fast moving trains. Post-tensioned concrete sleepers are used with a central steel rod, and again the system differs in details from the finally-established design.

The hot-forged bolts have parallel shanks and steel distance sleeves, as in the experimental system in this country. The round bolt heads have square extensions on the side opposite the shank, and these fit with considerable side clearance into square moulded holes in the concrete sleepers, at the bottom of the round bolt holes. The length of the diagonal of the square bolt head extension is, however, greater than the side of the square hole in the concrete, and this feature provides a safeguard against rotation of the bolt on tightening or releasing.

The square bolt head extensions, however, endanger the electric insulation between the metal components of the rail mounting and the sleeper, and although this was not of importance on the test stretch in question, this feature has been abandoned in the final design in favour of a square shank portion passing through a square punched hole in the baseplate.

The baseplate and rail clips are of standard type used in Austria, as is the wooden

soleplate placed between the rail foot and the baseplate, which was used as a matter of standard practice in that country. Before the laying of the Austrian track a set of extraction tests of the bolts from the sleepers was carried out by the laboratories of the Austrian Federal Railways. These had the particular object of determining the most suitable amount of axial compression of the sleeves. The bolts were of 22 mm standard Continental size and the rubber sleeves were of a tough, high-grade, natural rubber compound of about 72° Shore Hardness. The extraction loads from the concrete ranged from 2 260 kg to 3 900 kg per bolt. The rubber pads are plain pads throughout of a low-set synthetic compound. By way of experiment, a small proportion of the rubber pads has been vulcanised with a canvas insertion in the central plane to determine if this has any influence upon wearing properties. The test track has now been in service for well over a year without any faults being observed.

The authors wish to acknowledge the help and collaboration which they have received in this country from British Railways Research Department. In the development work in Austria the authors are much indebted for the assistance and collaboration received from Dipl.-Ing. Hofrat Kautz and Oberbaurat Petteln of the Directorate-General of the Austrian Federal Railways, and from Mr. F. H. Chlupac, who is the Austrian licensee of this rail mounting system.

Aluminium road bridge at Lünen.

(The Engineer, November 16, 1956).

On July 26, 1956, the first German aluminium road bridge was placed in position. This bridge (the Schwansbell Bridge, over the Datteln-Hamm Canal, near Lünen, Westphalia) has a span of 44.20 m, a clear width of 4.50 m, and a weight of 25 metric tons. It is suitable for lorries up to 12 tons (Class 12 of German standard DIN 1072). The bridge was built by Dortmunder Union Brückenbau A.G.

The Schwansbell Bridge, No. 464, over the Datteln-Hamm Canal, near Lünen, was placed on its abutments on July 26th this year. It is constructed of aluminium alloy and — in contrast with the aluminium foot-bridge erected in Düsseldorf in 1953, which is a plate girder bridge — is a lattice girder design. It carries local road traffic over the canal and is the first aluminium road bridge to be built in Germany.

The fact that in Germany aluminium alloy is a comparatively new and untried material for this class of work determined many aspects of the design. While it might have been preferable to employ more extensively ideas developed in connection with airframe construction, such as « shell » design, anisotropic decking and tubular sections, this course had to be avoided for two reasons. The nature of the order, especially the financial aspect, precluded any major experiment; moreover, it was desired to test as many different aspects of aluminium construction as possible. Consequently, a kind of design was chosen which allowed the structure to be built from a large variety of components. As may be seen from our illustrations, the bridge was built similarly to a steel bridge, but extensive use was made of extruded sections.

The material used was the alloy Al Mg Si F 32, which, in accordance with the German standard DIN 1725, has the following composition: 0.6 to 1.4 % magnesium, 0.6 to 1.2 % silicon, 0.6 to 1.0 % manganese, 0 to 0.3 % chromium, and the remainder aluminium. The alloy has an ultimate

strength of 3 200 kg per square centimetre, a yield point of 2 500 kg per square centimetre, and an ultimate elongation of 8 %. Permissible working loads, according to DIN 1073, were, for main and subsidiary loads: in tension, 1 460 kg and 1 670 kg per square centimetre; the same values for bending, both cases with a factor of safety of 1.71 for main and 1.5 for subsidiary loads. In shear, the working stresses were 880 kg and 1 000 kg per square centimetre with the same factor of safety. For cohesion the transition from plastic to elastic failure (Johnson parabola/Euler hyperbola) was at a slenderness ratio of 74.3. A safety factor of 1.71 to 2.5 was used in the plastic range and 2 to 5 in the elastic range. Rivets were of age-hardened Al Mg Si alloy according to DIN 1748, and working stresses of 700 kg and 800 kg per square centimetre were used for main and subsidiary loads, giving a factor of safety of about 2.

One advantage of light alloy construction is that use can be made of extruded profiles of almost any degree of complexity. Limitations are imposed, however, by the high cost of the tooling required, if this cost cannot be distributed over a large output. In the present case, the quantities were small and therefore profiles had to be chosen for which there would continue to be a market.

The capacity of the biggest available bar extrusion presses, which had a toolholder diameter of up to 400 mm, also limited the choice of sections to those which could be inscribed in a 350 mm diameter circle.

Existing stretching presses, used for straightening the extruded material, can deal with cross sections of up to 90 square centimetres.

It will be seen from figure 1 that because of limitations of the size of cross section which could be extruded and afterward subjected to the necessary straightening, the top booms had to be built up from two components, instead of a single section being used. The alternative would have been to extrude a section with a curved centre plate which could have been flattened out subsequently. While this would have been technically feasible it would have added to the cost. The fact that the booms are constructed of two Z-sections joined by riveting has the advantage that variations in width of the struts and ties can easily be accommodated by leaving the reaming of the boom rivet holes at the nodes, and the riveting itself, until these members have been put into position.

Another possibility for the booms would have been a rectangular box section either extruded in one piece or formed from two channels riveted or welded together. This was not chosen because of the problems of stiffening the walls of the box against buckling, and the need when using channels of having two longitudinal joints.

The bottom boom is built up from two channels back-to-back and enclosing the vertical and horizontal cross members. Between joints are placed a number of spacers. The smaller top flanges of the bottom boom channels are required to prevent deformation during manufacture and assembly.

The end diagonals are of the same section as the top boom, the others are I or $\square$ -sections, depending on whether they are ties or struts. Because of the small metal thickness of the I-sections, the edges are reinforced by bulbs. Top and bottom wind bracing is provided, the top wind forces being transmitted downwards through the portal frames at each end.

It was considered to be of particular importance to use a light alloy deck construction, rather than reinforced concrete. Experience in this respect was desirable

because it would seem possible on many existing bridges to replace the existing decking by aluminium; this would raise the load capacity, since up to 50 % deadweight can be saved.

The decking is formed of special « double T » sections with curved top flanges (see fig. 1). The increased stiffness of the curved flanges is intended to prevent deflection which could cause cracks in the asphalt layer 6 cm thick which is placed on top and which forms the road surface. The whole of the road deck is carried on three longitudinal beams spaced at the bridge centre line and 1.75 m on either side. Compared with a 16 cm thick reinforced concrete deck, weighing 384 kg per square metre, and a 5 cm asphalt layer (110 kg per square metre) — together 494 kg per square metre — the aluminium decking and 6 cm asphalt layer weigh 56 kg and 123 kg per square metre, respectively, making a total of 179 kg per square metre, which is substantially less. The lighter decking also makes possible a saving of about 1.6 tons of metal in the main girders. The footpaths are constructed of rolled sheet with a dimpled non-skid surface.

Thermal expansion is twice that of a steel design, and for the specification range of $\pm 35^\circ \text{C}$. the total change in length is 102 mm. Lintels had therefore to be used; these were made of « St 37 » steel in order to avoid excessive wear. To prevent corrosion, the steel was hot-dip galvanised and separated from the aluminium by an insulating layer. The bridge railings are made of extruded aluminium profiles which were anodised. The same shapes, but of steel, are used on the adits.

Construction.

In order to avoid contamination, especially of the joints, with iron swarf or filings, the fabrication was carried out in a separate bay of the works, equipped with radial drill, metal shears, circular saw and band saw. Both saws were of standard woodworking design for hand feed, equipped with special blading. All steel assembly jigs were carefully lined with wood in

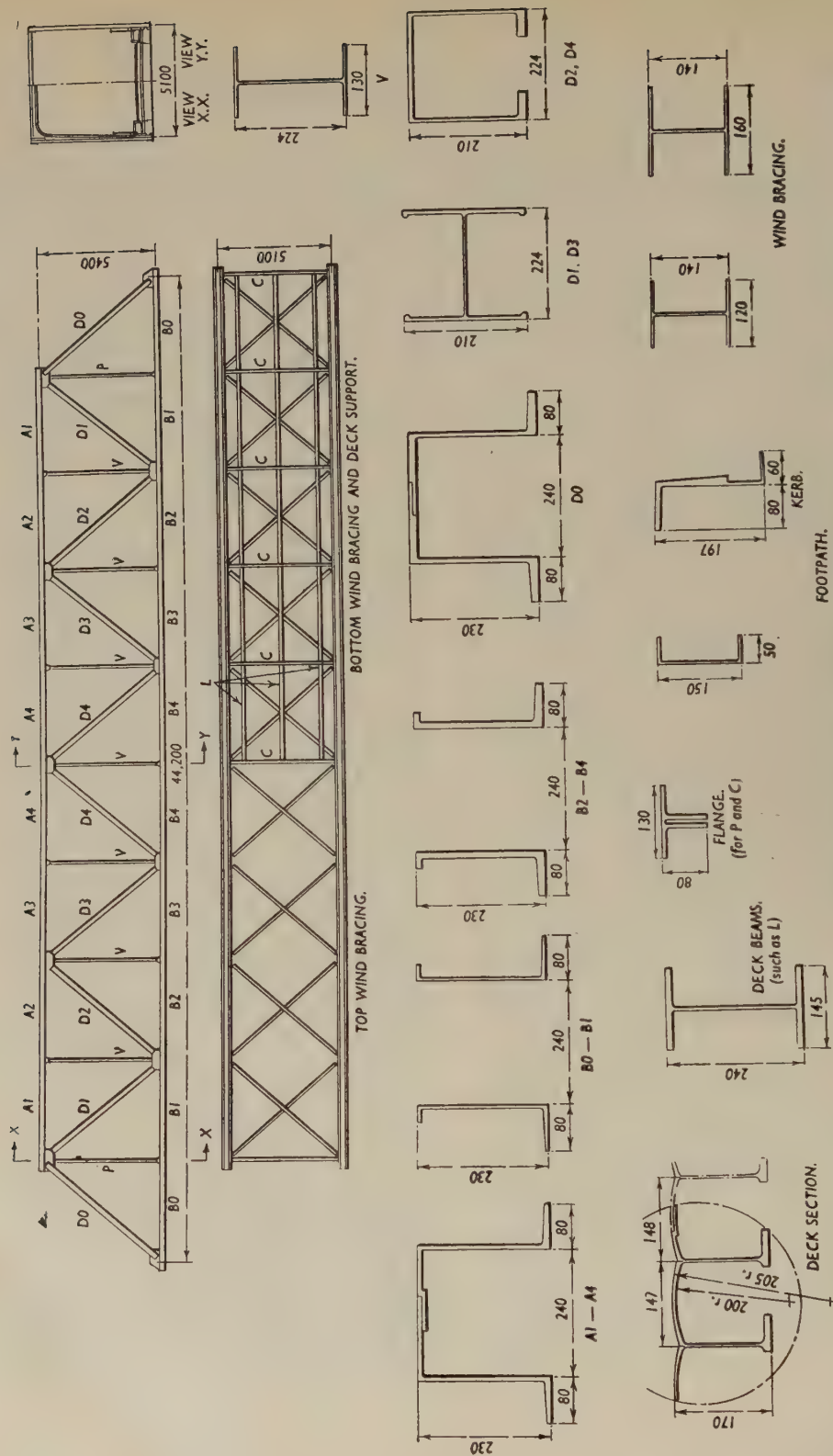


Fig. 1—Schwansbell road bridge. Details of the various extruded aluminium alloy sections of the bridge members are shown. All dimensions are in millimetres

order to avoid damage, especially stress-raising nicks and scratches. For the same reason marking-off was done with hard pencil and instruments made of plastic material. The shears table and clamp were lined with rubber sheet, as were the press bending tools used.

nents, which could be lifted by one or two men, no cranes or hoists were required for assembly. Zinc or cadmium-plated steel screws with aluminium washers were used. Holes were reamed to at most 0.2 mm over size. Rivets of 10 mm, 12 mm and 16 mm diameter were set in the cold by means of



Fig. 2. — Schwansbell bridge being placed on its sockets. It was transported to the site fully assembled by means of the two pontoons shown. With a span of 44.20 m and a useful width of 4.50 m, this aluminium structure weighs 25 tons. It is designed for lorries up to 12 tons.

Standard high-speed drills as for steel were employed, holes being drilled 2 mm under size for later reaming, and deburred with a hand-operated 120° countersink.

For bending the bridge deck sections at the centre by the required 1.5°, it was found necessary to clamp up the webs with hardwood liners to prevent buckling in the press. All grooves and blemishes were carefully removed everywhere by grinding or scraping.

Because of the lightness of the compo-

pneumatic tools specially adapted to avoid cuts and dents of the work. Many experiments had previously been carried out to find the best shape of rivet head for setting. This was found to be a pan head rather than a round head, the proportions depending on the rivet diameter. All joints were painted on the contact surfaces with a coating of « Lindolin F 64 ». It is not intended to paint the remainder of the structure, unless experience shows it to be necessary.

The bridge was completely assembled at the « Orange » branch works of Dortmunder Union Brückenbau A. G., at Gelsenkirchen, and was transported to the site by waterway. At each end one large cylindrical float was linked on, so that the bridge could be towed in a partly submerged position in order to clear various bridges. Several locks had also to be passed *en route*. On arrival, the floats were detached from the ends and placed underneath the bridge, one end being dealt with

at a time. This raised the bridge above the level of the banks, enabling it to be turned at right angles to the canal and floated against the piers. It was then raised on the abutments by means of two mobile cranes. Finally, the asphalt surface was placed on the deck.

The design and construction were carried out by Dortmunder Union Brückenbau Aktiengesellschaft, Dortmund, Sunderweg 86, German Federal Republic.

Prestressing a steel girder.

Renewal of a corroded railway bridge.

(*Engineering*, May 25, 1956.)



Fig. 1. — Livery-street road bridge, Birmingham, over the Western Region tracks, British Railways. The bottom chord of the single truss was so heavily corroded as to require strengthening and the decking had to be replaced. The tension in the chord was reduced by a prestressing load of 230 tons applied through eight Macalloy bars of 1 in. diameter.

Outside Snow Hill Station, Birmingham, the Western Region main line to the north runs adjacent to, and parallel with, the busy thoroughfare of Livery Street until, half a mile beyond the station, the line skews under the road at an acute angle. At this point, and as shown in figure 1, above, Livery Street bridge spans the Up and Down relief lines, the roadway being carried on cross girders resting on the top of a retaining wall on one side and underslung from a hogback truss girder on the other. This truss girder, 115 ft. long, spans from the retaining wall to a steel trestle between the Up relief and Down main lines, and the cross girders cantilever beyond it to carry a

footpath 7 ft. 6 in. wide. The bridge, of steel construction, was built in 1906.

The site is a particularly smoky one and the underside of the cross girders and, in particular, the bottom chord of the truss girder suffered severe corrosion. This weakening of the girderwork, coupled with the difficulty experienced in keeping a good surface to the road because of movement between the thin layer of road metalling (less than 5 inches in places) and the flat steel-plate decking, which was actually polished bright by the rubbing of the macadam, resulted in a decision to reconstruct the whole of the decking and to strengthen the truss girder. Though the road traffic could be diverted

without serious inconvenience to users, the strengthening of the truss girder spanning busy rail tracks, where clearances were insufficient to permit the erection of any temporary supports so that the dead load stresses could be removed, presented a difficult problem. Detailed examination showed the top chord and the web members, for the most part, to have been unaffected by the corrosion and to be in

Reconstruction order.

The reconstruction was undertaken in the early part of 1955. With the road closed to traffic, the decking was stripped, and while the old cross girders, under-slung from the panel points of the truss and spaced at 8 ft. 4 in. centres, were still in position, and after the web members and the tension chord had been

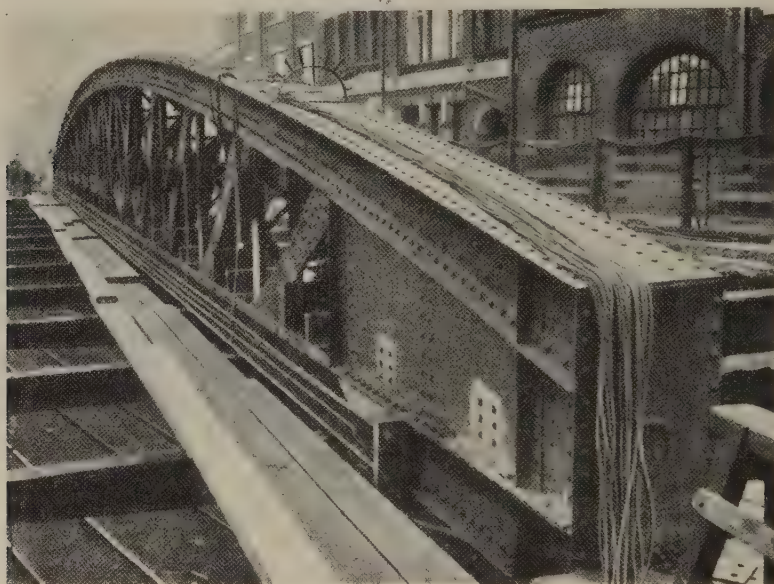


Fig. 2. — The main truss showing, on the left, the cantilevered beams below the footpath and, on the right, the girder below the roadway. Four of the prestressing rods are shown prior to being loaded.

good condition. So it was decided to strengthen the truss by prestressing the bottom chord after restoring the sectional area by the addition of steel flats welded to the vertical legs of the chord angles where corrosion had been the most severe, and to reduce the unsupported length of the compression chord by the addition of portal frames spanning the footpath and connected to the extremities of three pairs of the cross girders.

repaired, the tension in the bottom chord was reduced by a prestressing force of 230 t applied through eight Macalloy steel bars of 1 in. diameter, four on each side, as shown in figure 2. As may also be seen in this illustration, the rods were anchored to massive welded mild-steel brackets secured by high-strength bolts to the chord plates and flanges at points 3 ft. from each end of the girder. Two Lee-McCall jacks were used to stress the

bars, one bar on each side of the chord being stressed simultaneously, and this work in progress is illustrated in figure 3. The load applied to the first pair was greater than that applied to the next pair which in turn were stressed more highly than the next and so on, so that ultimately the load was the same on all eight bars.

to agree closely with those expected. Subsequently, the prestressing bars were wrapped in canvas and protected with bitumen before being encased in a concrete filling which covered the whole chord.

The new cross girders, hog-backed and all-welded, were placed in position by

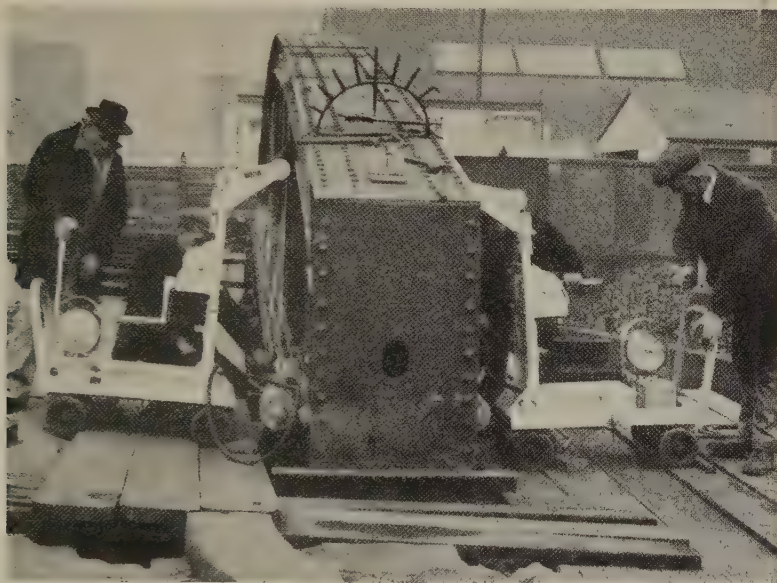


Fig. 3. — Eight prestressing rods were used in two frames of four. The load was applied simultaneously and equally to one rod on each side of the chord. The residual loads in the rods were designed to be equal.

Prior to stressing and throughout the operation the bars were temporarily supported at intervals of 14 ft. throughout their length. As a result of the prestressing, the chord shortened half an inch, the sliding bearing moving by that amount across the bedplate on the retaining wall; the camber of the girder increased by $\frac{7}{8}$ in. at the centre of the span. Changes of strain in the girder members were measured with electric resistance strain gauges and were found

cranes operating from the railway tracks below. Spaced at 4 ft. 2 in centres, they are pin-connected to new steel hangers passing through and bolted to the chord at points intermediate between the panel points of the truss; this arrangement allowed the steelwork to be fitted clear of web gussets and prior to the removal of the old cross girders. The portal bracings giving lateral support to the top chord have been connected to the ends of three pairs of the cross girders near

the middle of the span. The roadway, finished with a 3 in. thick layer of rolled asphalt on concrete, is carried on pre-cast reinforced-concrete jack-arches bedded on concrete skewbacks pre-cast on the bottom flanges of the cross-girders at the makers' works. The footpath consists of a layer of asphalt on pre-cast prestressed concrete planks, 12 in. by 3 in. thick, spanning between a continuous shelf angle on the steel plate parapet and a channel stringer adjacent to the truss girder. All exposed steelwork under the bridge has been protected with a coating of Ruberoid Plastic Compound No. 201 applied directly to the steel.

The bridge as originally built was designed to carry a 32 t boiler trolley drawn by a 15 t traction engine. The new decking and the strengthened truss girder have increased the capacity to 15 B.S. loading units, with a maximum axle load of 22 t.

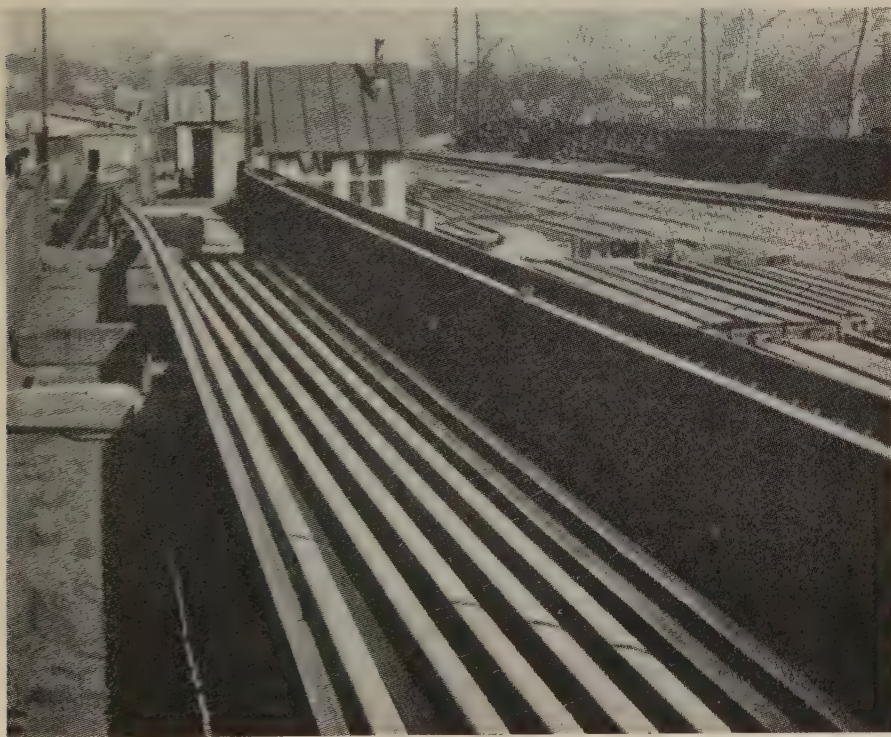
The scheme was worked out and detailed in the Steelwork Office under the direction of Mr. M. G. R. Smith, M.B.E., the Chief Civil Engineer, Western Region, at Paddington, and to the approval of Sir Herbert Manzoni, C.B.E., City Engineer, Birmingham. The new steelwork, 47 tons, was fabricated and supplied by Jesse Tildesley, Limited, Willerhall, Staffs., at whose works the concrete skewbacks were cast on the cross girders by A. F. R. Godfrey and Company, Limited. The pre-cast reinforced-concrete jack arches were made in the Western Region concrete depot at Taunton, and the pretensioned prestressed concrete planks for the footpath were supplied by the Bristol Stone and Concrete Company, Limited, Holcombe, near Bath. The site work was carried out by railway labour under the direction of Mr. J. R. Hammond, District Engineer at Wolverhampton. The strain measurements taken during the prestressing of the truss girder were recorded by the staff of the Research Department of the British Transport Commission under the direction of Mr. T. Baldwin, Superintendent of the Engineering Division at Derby.

How long rails were painted.

(*Railway Track and Structures*, November, 1956.)

The Norfolk & Western is trying out a new procedure to protect continuous welded rails laid in tunnels from the corrosive effects of moisture. The rails are now painted instead of oiled as formerly, and an interesting procedure has been devised to integrate the painting operation into the welding production line. This description of the procedure is based on an article that appeared originally in the road's employee magazine.

For use in tunnels...



After receiving a finish coat of paint, the rail is loaded directly onto flat cars for shipment to the site of installation.

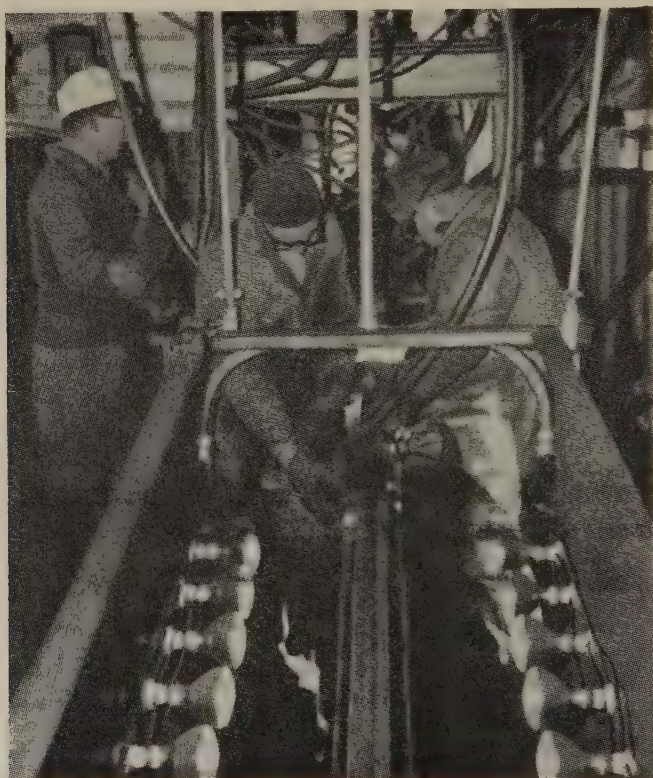
Why they are painted.

A number of years ago the Norfolk & Western became concerned over the increase in the number of head-and-web separations

occurring in rail laid in paved road crossings and tunnels. Stress measurements had shown that 131-lb. RE rail develops high tensile stresses in the web near its juncture with the head. These stresses were attributed to eccen-

tric vertical loads. Under ordinary conditions they were not sufficient to cause cracks to appear. It was concluded, however, that where corrosion was present the stress concentrations could eventually result in fatigue cracks. Thus, it was reasoned that the corrosive conditions present in paved road crossings and tunnels were an important contributing factor in causing the head-and-web separations. To prevent

How to apply two coats of paint to long rails as they are welded was a problem recently encountered — and solved — on the Norfolk & Western. Some years ago the road, as a protective measure against corrosion, started the practice of flame-cleaning and oiling long welded rails intended for installation in tunnels. When



Drying of the paint was materially speeded up through the use of infrared heat lamps.

the corrosion of rails at these locations, the road started the practice of flame-cleaning and oiling such rails before installation. At that time, it was estimated that rails treated in this manner would have a service life at least 25 % longer than if they were installed untreated.

* * *

it was decided recently to substitute two coats of paint for the oil it was apparent that a new problem in application had been created.

To eliminate additional handling of the welded rails to be painted, it was desired to apply the paint in conjunction with the

welding operation. The assembly line for producing continuous-welded rail by the Oxweld pressure-welding method is located at the road's roadway material yard in Roanoke, Va. The logical procedure was to apply the paint to the rails as they come from the welding production line. But to allow the paint to dry in the nor-

mal manner would cause excessive delays to the welding process. However, by heating the rail with infrared lamps the drying of the paint was speeded up sufficiently to permit the painting operation to be synchronized with the normal movement of the production line.

After the welds are finish ground, the rail moves along a roller line into a flame cleaner for removal of the mill scale. It then undergoes a wire brushing before passing into the first heating tunnel which is lined with the infrared lamps. As it leaves this tunnel, the rail moves through a small shelter where a painter on each side, equipped with a spray gun, gives it



Paint is heated thus eliminating the need for thinning. Two painters with spray guns painted rails at production line speed.

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Two different types of primer and finish

Tie plates are painted too...



Cleaned plates are placed on roller rack and sprayed as they pass a painter. They then move from the rollers onto a...



... conveyor belt on which they dry. At the end of the conveyor, the dry plates are removed and stacked for shipment.

paints were used. Three-quarters of the total footage of rail painted was given one coat of zinc yellow primer and one coat of box car brown paint. The remainder of the rail was painted with one coat of Neoprene primer and a finish coat of Neoprene paint.

Paint is heated too.

The operation features another time-saving innovation. Under normal conditions the paint would have to be thinned before spraying and would necessitate a second coat for sufficient coverage. Heating the paint, however, thins it sufficiently for use

in the spray guns and in effect allows a double coat to be applied as one.

After the completion of the painting process the rail moves on rollers through a drop-end gondola car and onto a string of flat cars. It is then shipped to the site of installation.

Tie plates, after a thorough cleaning with wire brushes, are placed on a roller rack and sprayed as they pass a painter.

They then move from the rollers onto a conveyor belt which allows them to dry as they move toward the other end. After the plates have traveled a sufficient distance for drying they are removed and stacked.

Painted rail has been laid in the road's Elkhorn Tunnel and Cooper Tunnel. It will be under continual observation to determine the effectiveness of the paint.

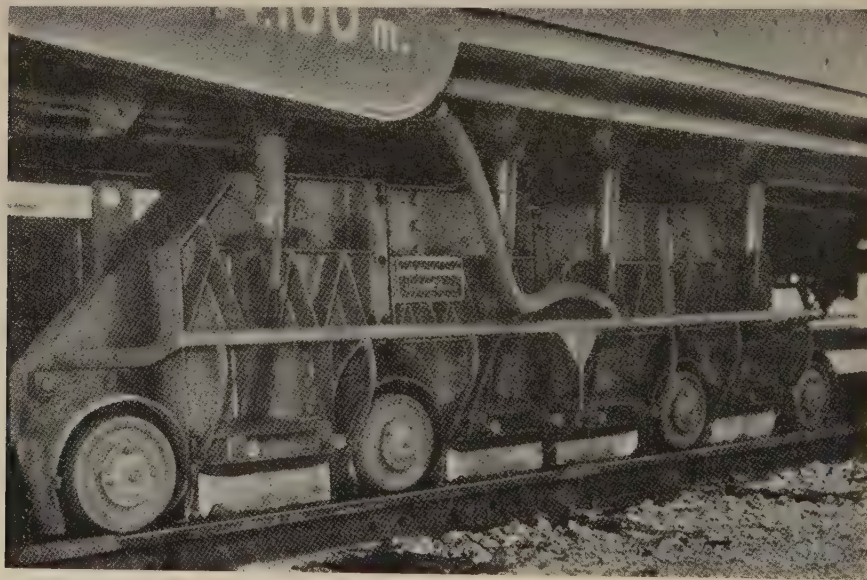
French National Railways rail grinding train.

Grinding shoes remove 0.02 in. corrugation by series of fast runs.

The Railway Gazette, December 7, 1956).

A serious problem confronting the railway civil engineer today is the maintenance of a smooth rail surface free from the effects of corrugation. This is not a problem peculiar to any one country, and many different railways have attempted to

maximum depth of 0.015 in. in a single run over a section of track at the comparatively slow speed of 1.8 m.p.h. The S. N. C. F. has recently been using a rail grinding train, of a basically different design, which removes corrugation by



Bogie of grinding vehicle, showing grinding blocks and guide wheels.

find a solution other than the replacement of the affected rail, which is, in general, not considered to be an economic practice.

In *The Railway Gazette* of November 5, 1954, a description was given of a German rail grinding train, incorporating rotating grinding wheels, which was said to be able to remove corrugations of a

means of non-rotating grinding shoes. This train, built by the « Société Scheuchzer » of Lausanne, operates at a speed of 24 to 28 m.p.h., but in order to remove corrugations of a maximum depth of 0.02 in., from 60 to 120 runs have to be made over the section of line from which corrugations are to be removed.

Composition of train.

The train, which has recently been operating in the Saint-Germain area, is normally moved by two locomotives, one at either end. There are two rail grinding vehicles in the train separated from the locomotives by runners, and from each other by two locomotive tenders; these two tenders provide water to lubricate the grinding blocks and to cool the surface of the rails.



Before grinding, showing corrugation.

The rail grinding vehicles have the appearance of second-class bogie coaches with reinforced undercarriages on each side. Each vehicle is equipped with 16 grinding shoes which superficially are not unlike the current-collecting shoes on electric locomotives with third-rail pick up; there are two groups of four grinding shoes on each side of the vehicle, each group also including four small-diameter guide wheels which keep the grinding shoes in correct alignment with the track when the train is travelling at speed.

Oleo-pneumatic legs, which are controlled by an electro-hydraulic device inside the vehicle, keep the grinding shoes in contact with the rail at a predetermined pressure.

Independence of vertical movement.

This type of assembly ensures that the grinding shoes are independent of any vertical movement of the vehicle, and adjusts



After six runs of grinding train.

the pressure applied to the grinding shoes according to the condition of the rail; it also compensates for the natural reduction in thickness of the grinding blocks.

Each block measures 15 in. long by 2.36 in. wide, and the effective grinding material on each block when new is 5.9 in. thick; the block is replaced when its thickness has been reduced to between 2 in. and 1.2 in. On the average, the blocks have to be replaced after each 120 miles covered by the vehicle with the grinding apparatus in operation. The abrasive block

is made of aluminium oxide grit with either magnesite or resin as a bonding agent; the grade and consistency varies according to the nature of the work to be carried out, the amount of wear and the hardness of the rails.

In the interior of the grinding vehicle, in addition to an instrument panel and control equipment located in the centre of the vehicle between the bogies, there is at each end accommodation for the staff of the train. At one end there is also a small workshop.



After 90 runs of grinding train.

When it is desired to put the train into operation at the request of the Permanent Way Department, the section of line to be dealt with is accurately marked out. Normally the rails on each side of the vehicle are ground simultaneously, but in the rare case where one rail is worn

more than the other the apparatus can be adjusted to grind one rail only.

Application of grinding shoes.

Having arrived at the appropriate point, the grinding shoes are brought into contact with the rail and a total pressure of 4 to 5 tonnes applied to the 16 shoes. This pressure is gradually increased to 10 tonnes, the speed of the train being maintained constantly at 24 to 28 m.p.h. To grind successfully the rails on the section between Saint-Germain-des-Fossés and La Palisse it was necessary for the train to make 60 runs at maximum pressure and speed, at the rate of 10 runs a day.

The speed and pressure at which the trains operates results in the rails becoming very hot, the water from the tenders being applied liberally to prevent structural deformation and to ensure the maximum abrasive effort.

The Permanent Way Department of the S. N. C. F. has expressed considerable satisfaction with the technical results achieved by this grinding train, and its use is to be extended widely. From the operating aspect, the S. N. C. F. appears to consider that it is more economic, and the cause of less interference with other traffic, to make several runs on a fast schedule rather than one very slow grinding run, which would entail long occupation of a section.

To get the best results from the economic point of view it is desirable for the train to cover, while working, at least 62 miles each day. The greater the distance the better economic proposition the train becomes; it should be borne in mind that after covering 120 miles it is normally necessary to replace the grinding shoes and to fill up with water.

Besides operating in the Saint-Germain area, the train has been used on the Paris-Bordeaux and the Paris-Le Mans-Rennes lines. At a later date it is to work on the Paris-Lyons line.

N.E. Region track-lifting and scarifying unit.

Scarifying formation and breaking up old sleeper beds in advance of track renewal or ballasting without removing track.

(The Railway Gazette, November 9, 1956).

A new track-lifting and scarifying unit is now in service in the North Eastern Region of British Railways. It is being used to scarify the formation and break up old sleeper beds immediately in advance of a track renewal or ballasting, without removing the track.



Scarifying unit being towed along under track.

The one-piece unit has been under development on the North Eastern Region for some time; it is basically on similar lines to a Swedish type. It is 8 ft. long and 10 ft. 6 in. wide and consists of a flat steel plate base with two rows of scarifying tines welded to the underside in chevron formation. A detachable plough can be fitted in the rear of the tines. Three arched ribs, one

central and one under each rail, are fixed on top of the base plate which is also strengthened with transverse members, the whole resembling an inverted sledge with upward curved runners. The unit, weighing about 1 1/2 tons, is thus designed so that, when moved longitudinally under the track being ploughed, its own, and the weight of the track, are concentrated upon the tines for scarifying.

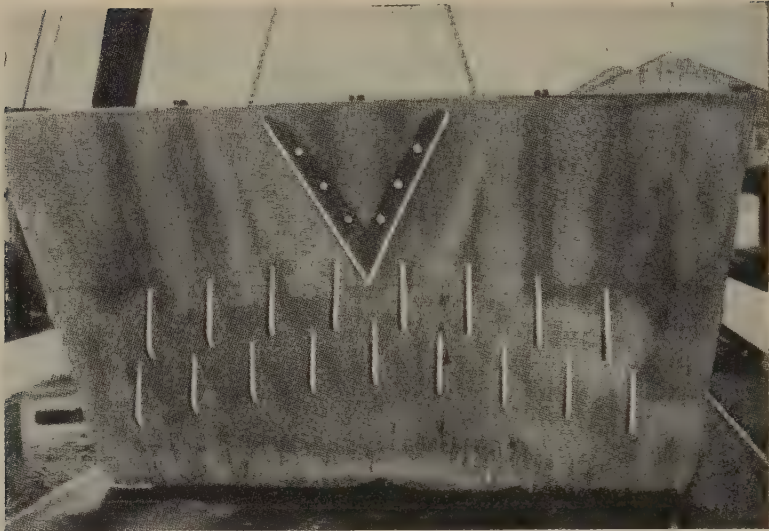
At the point where the scarifying unit is to start work, the track is jacked up to enable the unit to be inserted under the sleepers. When the jacks are removed the track sleepers rest on the arched ribs, and as the unit moves forward the rib noses are forced under succeeding sleepers which then slide up over the curved or arched ribs to form a hump in the track, as illustrated.

Towage by locomotive.

The unit is towed by a locomotive through a harness consisting of four wire ropes and a spreader bar. By adjustment on the shackles fitted to the wire ropes, it is possible to offset the unit up to 12 in. (sleeper ends permitting) over a short distance.

The track boxing ballast is redistributed by the plough, leaving the track about 2 in. above its original level. If desired, by fitting the detachable plough unit, some scarified ballast can be diverted from the centre of the sleepers to beneath the rails, to reduce risk of subsequent centre-binding. It is also possible to provide still greater additional depth of ballast beneath the track by distributing new ballast on to the track ahead of the plough.

It is found that the normal penetration of the scarifying tines into old sleeper beds



Under-side of scarifying unit lifted to show tines and plough.

is about 5 1/2 in., and that the general disturbance of old ballast containing a proportion of dirt effects some measure of top ballast cleaning.

These units will, it is understood, shortly be used in the North Eastern Region in

conjunction with the newly reconditioned Morris Tracklayer in the application of further mechanisation of track renewal work under single-line occupation, and also on a programme of augmented track strengthening work.

NEW BOOKS AND PUBLICATIONS.

[385 (09 .3 (469)]

Centenario dos Caminhos de Ferro Portugueses. (*The Centenary of the Portuguese Railways*). — *Gazeta dos Caminhos de Ferro* of the 16 th October 1956 and *Boletim da C.P.* for October 1956, respectively of 90 and 64 pages, illustrated. — *Gazeta dos Caminhos de Ferro*, Lisbon, Rua da Horte Seca, 7, 1º. — *Boletim da C.P.*, Lisbon, Largo dos Caminhos de Ferro, Estação de Santa Apolónia.

These two periodicals have devoted an entire issue to the centenary of the inauguration of the first Portuguese railway line.

The first section of line was inaugurated on the 28th October 1856. It started from the capital and its terminus was Carregado. The *Boletim da C.P.* recalls in a brief note the ceremonies which took place at this historical moment.

To begin with, various eminent personages, amongst them the Minister of Communications, expressed the sentiments aroused in them by the centenary of the birth of the Portuguese railway system. Homage is paid to the pioneers of the first days and to those who at all degrees of the hierarchy worked to perfect it.

Further on the vitality of the railway and the benefits the country has derived from it are thrown into relief.

Many other diverse subjects are dealt with, some of them of historical interest, others of a technical, commercial or social nature.

In the *Gazeta dos Caminhos de Ferro*, much space is reserved for the historical notes.

A moving evocation of the great figures of George and Robert Stephenson serves as an introduction.

The Maria Pia bridge, a great metal structure that crossed the Douro in a single span was completed in 1877. The author links up its history with a souvenir of its creators, amongst whom was the celebrated engineer Gustave Eiffel.

The work contains many contributions recalling the beginning and successive developments of the railway, each dealing with some particular subject.

The programme of the centenary celebrations, which is very imposing, is given in a note by the President of the Administrative Council of the P.R. The culmination is to be the inauguration of electric traction on the original line of the system. The Lisbon-Sintra section was the first to benefit by the advantages of the new technique. It is a noteworthy fact that the Portuguese Railways have used the most up-to-date system, that is high tension current at industrial frequency, thus proving their desire for perfection.

E. M.

[388]

Prof. Dr.-Eng. W. LAMBERT. — *Nahverkehrsbahnen der Grosstädte.* (*Methods of transport for large cities*). — One volume in-4º of 72 pages with 42 figures, 68 tables and 47 plates. — 1956, Berlin W 35, Springer-Verlag, Reichpietschufer 20. (Price : DM 15,—).

A study of the methods of transport most suitable for large cities, a subject that has become increasingly topical owing to the increase in the number of cars on

the road during recent years, is the subject of a very thorough and solidly documented work by Professor LAMBERT, Director of the Institute for the study of transport of

Stuttgart University, which has just been published.

This work, which deals in a very thorough way with the subjects covered, and includes numerous appendices giving plans, constructional diagrams and calculations for detailed analyses, is the result of a considerable amount of study of the various solutions applicable to cities of 0.5 million inhabitants and over, based on the use of the railway for the urban and suburban transport services: ordinary tramways, tramways on their own site, underground or overhead metropolitan railways.

The studies have covered 56 types of construction of tracks and 28 different arrangements of stopping points.

The information to be found in the book, especially in the appendices, covers the essential technical problems and economic aspects which condition the construction and the financial results of the capital invested; for those who have to

deal with such problems it will be a very complete vade-mecum, the data being given in the form of both graphs and plans as well as tables of figures. For example, the influence of various types of soil and sub-soil, as well as the different methods of building the lines can easily be determined from the data given.

By using the economic results obtained in current cases, the author finds that the construction of a metropolitan railway, whether underground or overhead, is rarely a paying proposition on the single basis of the expected traffic. The financial problem obviously takes on a different aspect when the public authorities or government take over some of the costs of construction, since they are thereby saved from the cost of keeping the roads clear and improving the flow of motor traffic in the middle of our present-day cities.

P. SCH.

[385 (09 (3)]

World Railways 1956-1957. A worldwide survey of railway operation and equipment. — *Fourth edition.* — Composed and published by Henry Sampson. — One volume (8 3/4 × 13 inches) of 502 pages, illustrations and maps. — 1957, London W.1, Sampson Low's « World Railways Ltd. », 25 Gilbert Street. (Price : £ 4.4.0 d).

The third edition of this important work came out in 1955. The interest with which it was received by the rather specialised albeit numerous section of the public to which it is addressed can be judged from the rapidity with which the new editions follow each other, as well as the care taken by the author to keep it up to date.

There are two important parts in this large volume. The longest includes information concerning the railways. These are grouped by continents and given first of all in alphabetical order in tables giving their main characteristics. Then the chief railways are again dealt with separately and in greater detail, with the most up to date maps of the systems. The rolling stock, the financial results and the traffic

are amongst the data given. In addition, to show present day tendencies, the author reports any modifications made or proposed during the year in the various fields, such as traction engines, electric traction, welding rails, etc.

The other part, which is almost as long, deals with the constitution and activities of locomotive and rolling stock manufacturers. The new productions of the two last years are reviewed and shown in drawings together with their leading dimensions.

Electric traction which in principle has displaced steam is now faced itself with formidable competition. The author deals in his foreword with the present position of such competition wherever it is strongest. In addition, in a special section devoted

to Diesel traction, he gives all the characteristics of the Diesel engines built by the manufacturers of twelve different countries.

In the same foreword, there is a synthetic report of the most recent improvements made by the railways and the results obtained in their search after efficiency and economy.

Four special notes at the end of the book complete this survey of the evolution of railway transport. These deal with the following subjects: radio on the railway, long welded rails and the fastening of rails, light trains, and mechanisation of permanent way maintenance.

From the great amount of information

contained in this volume there is clear evidence of the progressiveness of the railways both as regards their equipment and their operating methods. On nearly every page, we see how they wish to make the fullest use of the conquests of science and modern technique. In this order of ideas we may mention again the ever increasing use of centralised traffic control, the powerful gas turbine locomotives and the electronic brain controlling the speed of wagons in marshalling yards.

This volume gives a complete picture of the railways of the world, and throws into relief the striking features of their present day make up.

E. M.

[313 : 656 (494)]

Schweizerische Verkehrsstatistik 1955. (*Swiss transport statistics 1955*). — One volume (8 1/4 × 11 1/2 inches) of 158 pages and 8 graphs. — 1956, Bern, published by the *Berne Federal Transport Office*. (Price : 12 Swiss francs).

Tourist country par excellence and situated at the crossroads of all the great European arteries, Switzerland attaches the greatest importance to its railways and other methods of transport. These form an essential and primordial part of the national economy, and the people of Switzerland have always been very interested in their working. It can be understood therefore that these transport statistics which the Federal Office takes great pains in preparing are always awaited with curiosity.

From the numerical tables which form the greater part of the volume and the graphs which complete them, the interested reader will be able to see for himself the true situation of all the different methods of transport, the amount of traffic dealt with, and the financial results. The remarks made in the foreword have already informed him of the special features of the year 1955.

The most extensive statistics relate to the general railways, but those relating to the special railways: rack railways, funiculars and telfer railways, are equally instructive.

The year 1955 was a prosperous one. The Swiss Federal Railways had a record amount of freight traffic and an appreciable increase in their passenger traffic. In spite of the considerable rise in costs, the operating coefficient improved to 67.2 %. On the private railways, the improvement was not general, but on the whole the operating coefficient was also lower (86.8 %). Certain undertakings suffered from the effects of road competition.

All the figures recorded show that road traffic is ever on the increase. In spite of this, local traffic (tramways, trolleybus and omnibus services) was higher than in the previous year.

Increased activity favoured the tourist lines. New lines were put into service.

The report gives details about the navi-

gation on the lakes and the Rhine. This results in additional railway traffic, but to an ever decreasing extent.

The final chapter deals with air traffic. The transport dealt with by the air lines and air ports increases from year to year. Swissair transported 18.8 % more than in 1954. Its operating coefficient fell to 88.1 %. As regards destinations, European

traffic predominates, and the greater part comes from Great Britain.

The abundance and great diffusion of the overground transport which makes it easy to reach every part of the country are no doubt some of the factors which contribute to the successful picture.

E. M.



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